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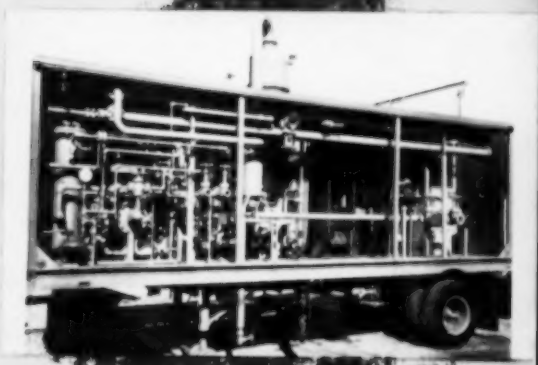

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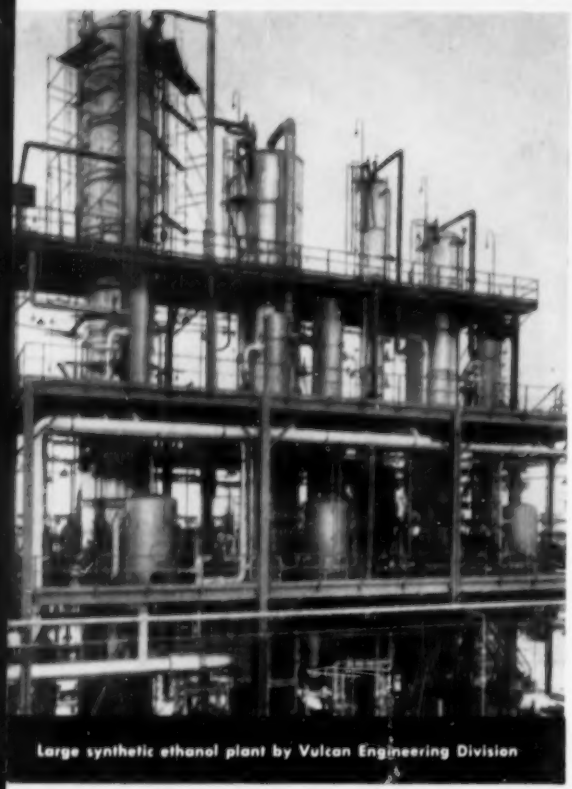
REVOLUTION IN PULP AND PAPER TECHNOLOGY?

Midget hydroclones remove micron particles

PLUS: Innovator vs. organization man
Labor's drive for engineers
Status of membrane demineralization
Helical-flight mixers
Fluidized bed for UF_4
Cuban nickel uses Chemico reduction
Engineering firms and computers
Registration—professional or legal?
Inorganic raw materials—where, when?
Shrouded pump impellers
Plastics futures—walk, don't leap
What happened at oxygen plant safety conference

process know-how for . . .

ETHANOL



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Chemical Engineering Progress

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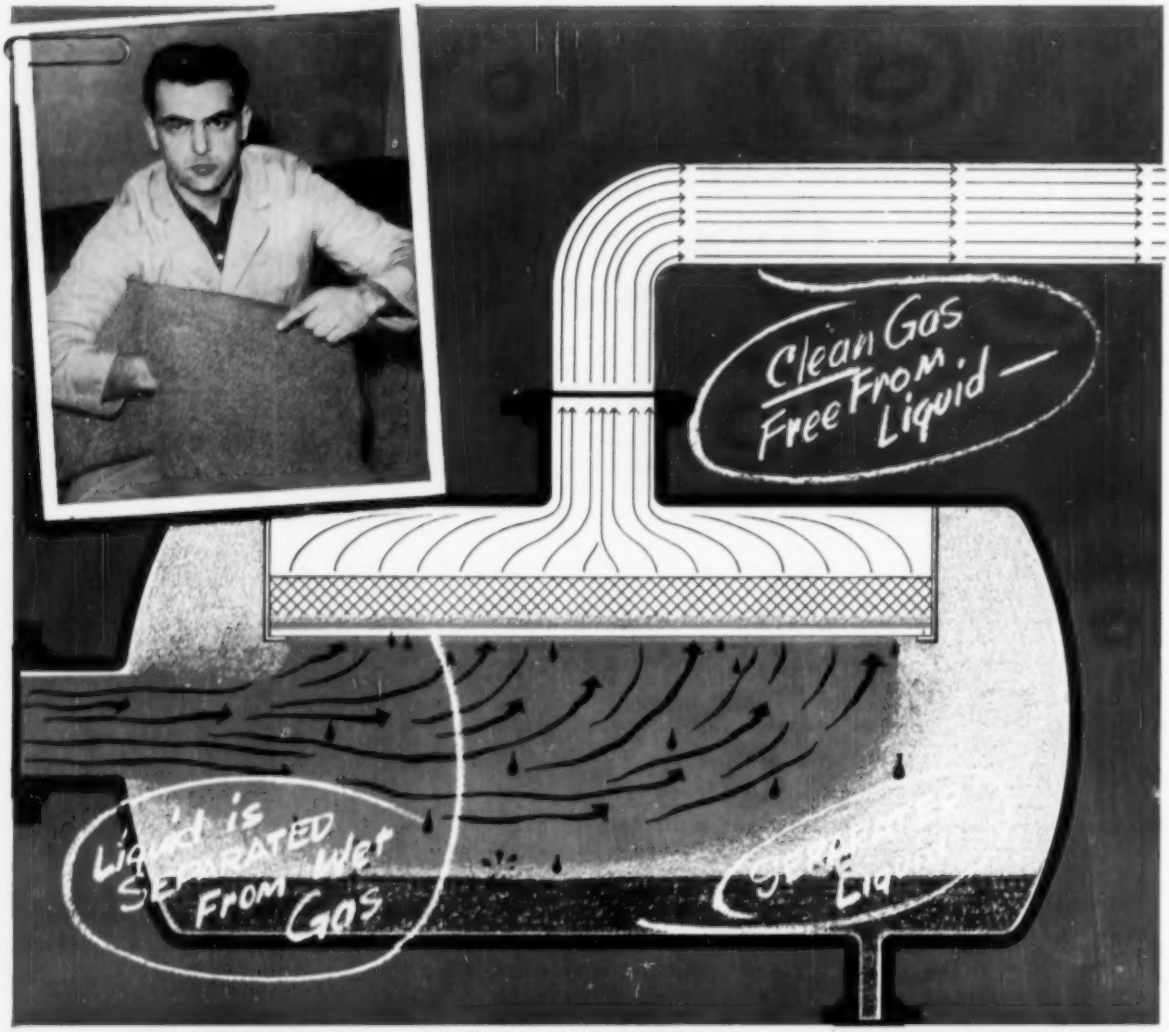

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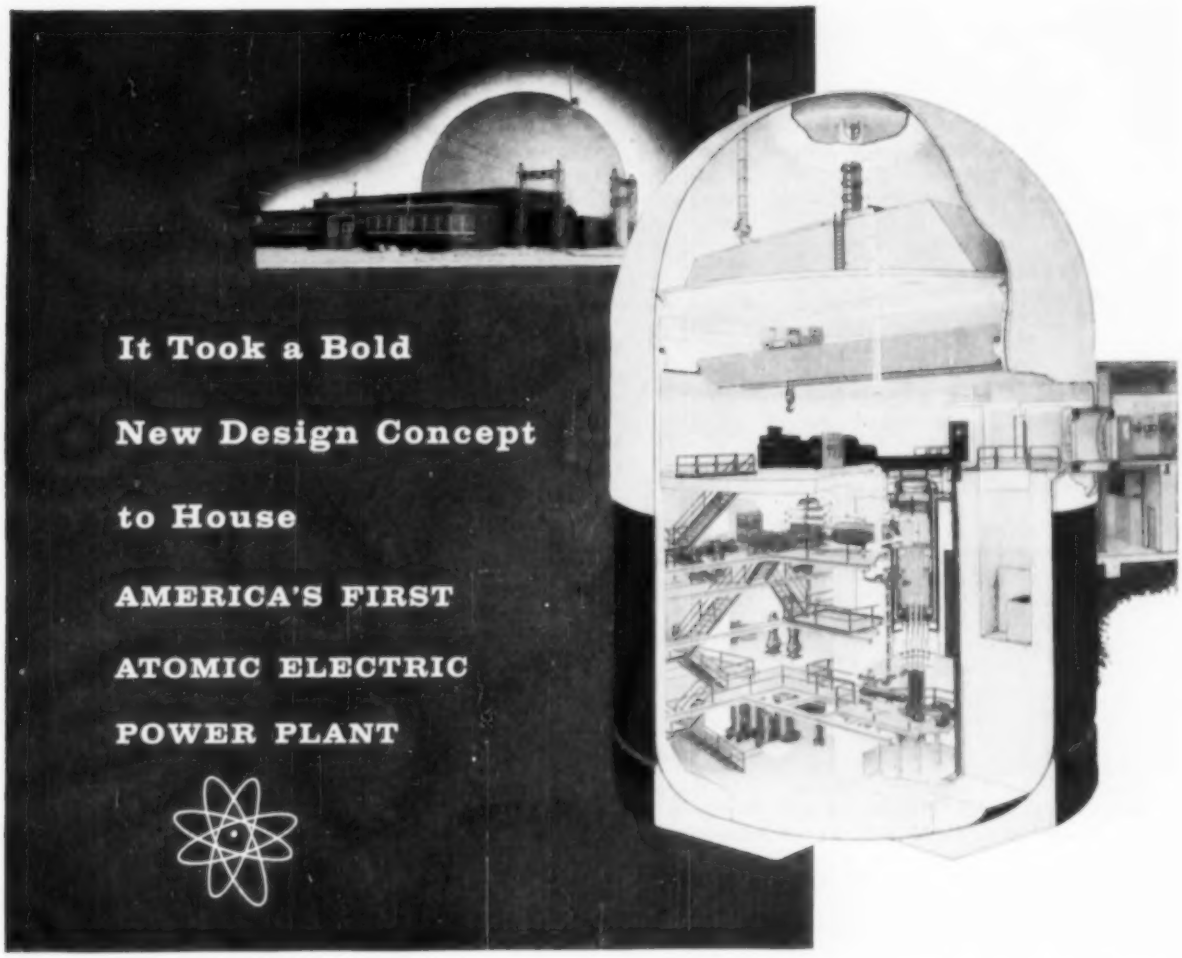

How do you house an atomic electric power plant? Dig a hole five stories down. Erect a giant ten-story welded steel "containment vessel." Seal it off air-tight, and you have one of the largest pressure vessels man has ever been called on to build.

That's the story, over-simplified, of the unique housing required for America's first nuclear-powered electric plant, the Experimental Boiling Water Reactor, at Argonne National Laboratory, Lemont, Illinois.

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Radioactive steam and gases must be contained within the system. The precautions necessary demanded an air-tight building, 80 feet in diameter by 119 feet high.

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ORGANIZING ENGINEERS INTO UNIONS

Speaking to an A.I.Ch.E. audience at White Sulphur Springs, chemical labor leader O. A. Knight briefly discussed unionism and the professional. But in his printed text, released prior to the meeting, Knight went much further into the subject. *CEP* feels that this elaboration of the action, predictions, and views of a prominent labor leader in the chemical industry should be brought to the attention of every chemical engineer.

O. A. (Jack) Knight, president, Oil, Chemical and Atomic Workers International Union (AFL-CIO).

There is a great mutuality of interest between professional men and labor. The professional in industry and the laborer both work for an employer—for a wage or salary. Both sell their hands, their skills, their minds, and their sweat. Both depend for a living on their ability to do a job of work, rather than on investments or financial management. The professional man is, of course, better educated. By and large, he has spent more time learning his skills. I do not suppose any members of my union will disagree with me if I say, therefore, that the professional man typically is entitled to a higher rate of compensation.

But while both the laborer and the professional man are wage or salary earners, there are differences in their requirements. The laborer, even the highly skilled laborer, does work that is relatively more routine. He needs security and his work is adaptable to relatively rigid seniority systems of promotion and demotion.

The professional man typically does a more individualized type of work. He is not so concerned with hours of work. He is less concerned, at least at present, with job security. He is more concerned with opportunities for individual advancement.

More Professionals

In the past, professional chemists, engineers, etc., have represented a relatively small percentage of our total work force. Because they were few, professionals in industry found it generally practical to engage in individual bargaining.

This is changing. The professional force in industry is growing larger in number and much larger as a percentage of the work force. Where once a company counted its professionals by the dozen, the same company now counts them by the hundreds and in some cases by the thousands. The professionals are becoming cogs in a mass-production—an almost assembly-line operation.

This trend is alarming to some engineers. They are becoming concerned about the question of organization among professional men, that is, organization for collective bargaining purposes, not just as professional societies.

Our union has been making some studies of the needs of technicians and professional men for collective bargaining organization, seeking to determine what their needs and desires are in the field of compensation and working conditions and how they would like to go about securing the improvements they desire. No conclusions have been reached in this study, but we are continuing to accumulate information.

(*Continued on page* 10)

DO WE NEED "NUCLEAR" ENGINEERS?

No, says AEC's director of Reactor Development W. Kenneth Davis—on basis of both government and industry needs.

W. Kenneth Davis

What is the definition or description of a nuclear engineer? . . . I do not believe that there is any more need for a new engineering field called nuclear engineering than there was for a new area called chemical engineering. You may argue that history has demonstrated the need in the case of chemical engineering. The same history also shows, however, that the older fields of engineering were not willing or able to adapt themselves to new concepts and requirements, and that it was thus necessary for a new field to be created which otherwise might never have been needed. . .

The atomic energy industry, governmental and private, as it stands today, and as a shadow of the future, employs a wide variety of people for its research programs, its design and construction projects, and for the operation and maintenance of its plants and facilities. . . it is significant that the AEC is striving to reduce all operations to as nearly an industrial basis as is feasible and to transfer responsibility to private industry as quickly as possible. . .

The AEC itself employs about 600 engineers. Most of the engineers in the atomic energy program work for AEC contractors who employ about 10,500. Another substantial number of engineers are now employed by industry on private atomic energy work. A reasonably good estimate is that 1½ to 2% of the country's 700,000 engineers are employed in some aspect of the atomic energy program . . . they are mostly engaged in their usual type of engineering work without reference to any special requirements. However, there is a substantial and growing number of engineers engaged in research, development, design and operation of reactors, and specialized facilities required in reactor systems . . .

Perhaps two thirds to three quarters of the engineers are today engaged in the military reactor programs. . . This is of particular significance inasmuch as the requirements for civilian applications, as they develop, call for several new considerations, an important one being reduced cost. . . Engineers always had an important place in the construction and operations phases [of atomic energy] but [there has been a significant increase] in the research and development phases where they had only a small place.

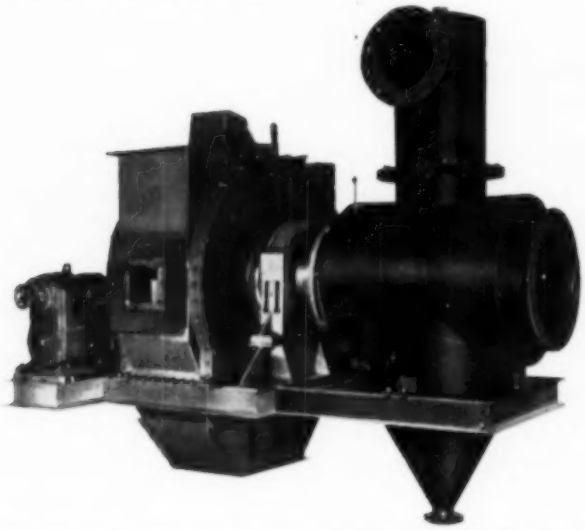
Not Nuclear Engineering

Neither logic nor practical evidence

(*Continued on page* 28)

EIMCO DRYER HANDLES ABRASIVE CRYSTALLINE SLURRY

Decision of a large American producer of gas, fuel and chemical by-products to install an Eimco Top Feed Continuous Vacuum Dryer, was the result of their need for equipment to dewater and dry Ammonium Thiocyanate.



The extraction of this chemical from coal is unique to this company.

The processes used produce NH_4CNS in crystal form and the crystals are precipitated prior to drying. The extremely corrosive slurry is fed to the Eimco through a 20 × 20 mesh screen, .019 inches open.

Stainless steel materials of construction have resisted the highly abrasive physical characteristics in the feed to provide trouble-free, low maintenance service since 1941.

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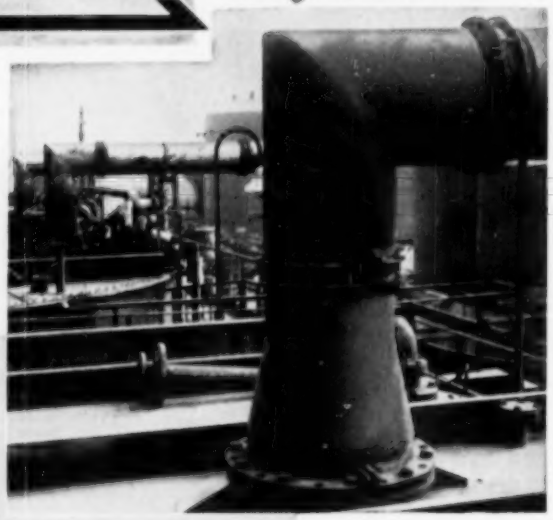

HAVEG DUCT solves SO_2 fume removal problems

RESISTANCE TO ACID ATTACK MAKES THE DIFFERENCE AT ATLANTIC REFINING COMPANY ACID PLANT

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Noted and quoted

(Continued from page 8)

If we find a sufficient interest on the part of technicians and professionals, we intend to offer organizational opportunities to them. We recognize in advance that if professionals organize, they would not want the same sort of contracts we negotiate for hourly-paid workers. We do not know yet whether professionals are substantially interested in organizing for collective bargaining purposes at this time. We do not know whether they would like to organize as separate divisions of existing unions, or if they would like to organize separately. We are exploring and studying the subject of organization among professionals, but we are not at this time attempting to organize them.

Professionals Should Organize

Apart from my union's intentions and plans, I have definite opinions about the broad general theory of organization of professionals for collective bargaining purposes.

The opinion I hold is simple: professionals should organize for collective bargaining. The pride the professional man holds in his professional level should not be a deterrent to organization for raising his economic level, his security, his conditions of work. In the long haul, the owners of industry are just as interested in cutting their payroll costs in the professional fields as they are in cutting their payroll costs among their common labor, semi-skilled and skilled labor. The owners are going to hire a man as cheaply as they can; there is no alternative under free enterprise than for the wage or salary earner to fight for compensation as high as he can.

Of course, I need not remind you that two of the strongest unions in America are among professional men. I refer to the American Medical Association and the American Bar Association. These unions of professional men fix compensation rates, control working conditions and impose the most rigid closed shop conditions ever found in democratic nations.

There is no inconsistency between unionism and professionalism. On the contrary, they spring from the same roots. . . . Professional men in industry are now in the position that craftsmen were a century ago. Now they are exceptionally skilled men selling their exceptional talents as a means of livelihood. They are in demand. They are an elite class. They still work generally on the basis of individual skill and ability. . . . But at the risk of venturing into a subject with which I am not too well acquainted, I would suggest that their

(Continued on page 12)

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Mercury Arc Rectifiers

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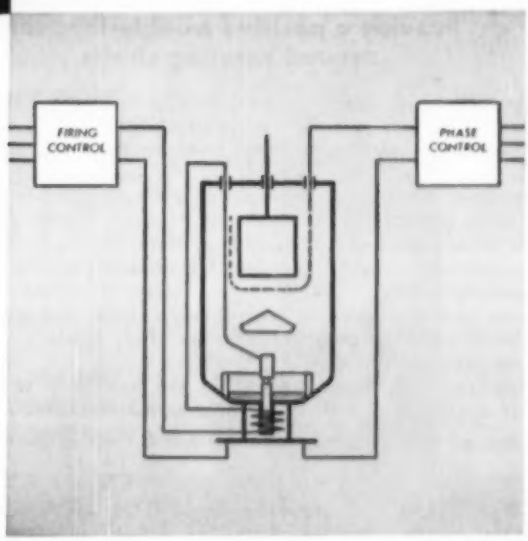

Only Excitron Rectifiers Provide Separate Circuits

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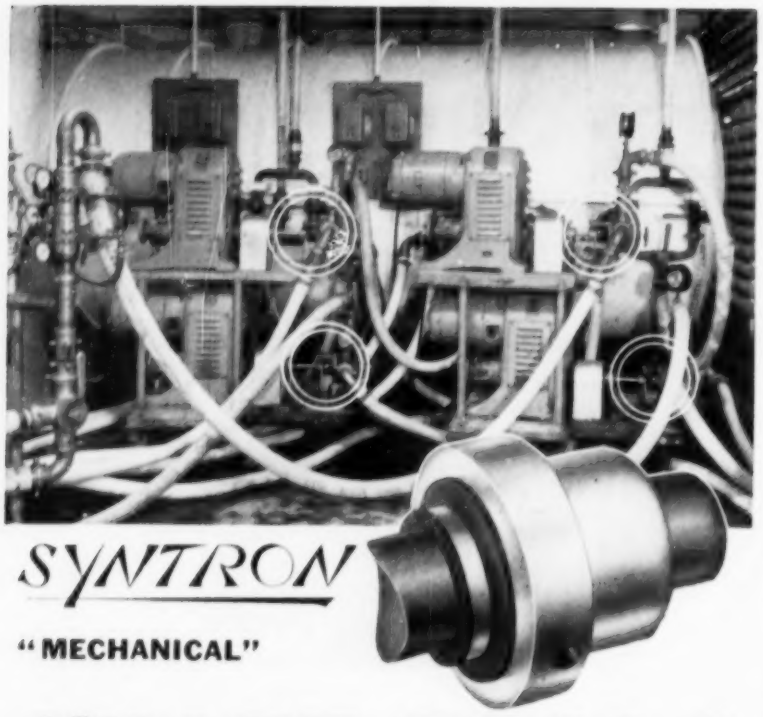

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Syntron Shaft Seals are built as a single, easy-to-install unit. Seal faces are lapped to precision flatness. Inner sealing parts rotate with shaft—will not score or damage shaft. Self-lubricating, automatic pressure balance eliminates periodic adjustment and maintenance.

Stop leak waste, lower maintenance costs. Solve your sealing problems with Syntron Mechanical Shaft Seals . . . seals of proven dependability.

Syntron's years of experience are available to you—write to our application engineers for recommendations.

Builders of Quality Equipment for more than a Quarter-Century.

Other SYNTRON Equipment of proven Dependable Quality

HOPPER LEVEL SWITCHES

FLOW CONTROL VALVES

SPIRAL FEEDERS

Write for complete catalog data — FREE

SYNTRON COMPANY

116 Lexington Avenue Homer City, Penna.

Noted and quoted

(Continued from page 10)

work, like the old-time craftsman's, is becoming more and more a mass-production, assembly-line operation. More and more professional men are working for a fixed salary and fringe benefits rather than as individual enterprisers who set their own fees.

In this context, it seems inevitable to me that there will be an increasing degree of organization for collective bargaining purposes among professionals.

That segment of labor which I represent—the organized hourly-paid workers—recognizes an affinity of interest with those professionals employed by industry on a salary basis. The professionals are a rapidly growing part of the company payrolls. Relatively speaking, hourly-paid workers represent a decreasing percentage of the company payrolls. Between laborers and professionals there is growing a vast army of technicians . . . men of semiprofessional status.

The hard fact of economic life is that in obtaining better pay and working conditions from massive corporations, the greatest possible degree of unity must be achieved among those who draw paychecks from these huge employers.

Recognition of this fact led to the development of industrial unions in the mass-production industries to replace the divisive old craft unions. It is now generally accepted in organized labor—even among former craft union advocates—that in industrial plants there should be one union for all workers rather than a dozen or so craft unions.

Recognition of this fact leads us in Labor to recognize that we need a working relationship, now, with the professionals who number by the hundreds and the thousands in each of the major companies we negotiate with.

Do not misunderstand me: I am not suggesting at this time that professional men should affiliate with the present unions of hourly-paid employees. Frankly, our further studies may lead us, in the future, to make such suggestions. All I am saying now is that there is a mutuality of interest and there should be a working relationship between the professionals employed by large chemical companies and the hourly-paid men employed by the same company. Whether this relationship should take the form of cooperation between separate organizations or uniting of the two groups in the same organization remains to be seen.

(More Noted and Quoted on page 28)

AN ANNOUNCEMENT OF SIGNIFICANCE TO PRODUCERS OF POWDERED MATERIALS...

In Search of IMPROVED PRODUCTION CONTROL

Quick facts about top size, percentage of fines, average size, acceptable limits—these are but a few of the essentials for precise product control of powdered materials.

However, by time-honored methods of particle size analysis, such facts take so long to obtain that they are generally of little day-to-day and batch-to-batch value to production. In addition, these methods have the disadvantages of relatively poor reproducibility, inaccuracy, paucity of data and require trained personnel.

With particle size distribution data available in a matter of a few minutes or at the most two hours, a whole new world of quality control data is put at production's fingertips. Process variations are discovered and corrected "as they happen"; normal standards may be raised; techniques are verified; production planning is simplified . . .

The Sharples Micromerograph is the one instrument that can provide rapid reproducible particle size distribution determinations at production speed, with accuracy within 3%. A relatively large sample (1/10 gram approx.) is analyzed in as short a time as 15 minutes, and the analysis is permanently recorded on a chart. No particular skill is required of the operator.

The Micromerograph has paid for itself quickly in numerous production control laboratories and is so fast and accurate that research is often carried on at the same time.

We invite you to investigate thoroughly the remarkable benefits of this exceptional instrument. Bulletin 101 will be sent upon request.

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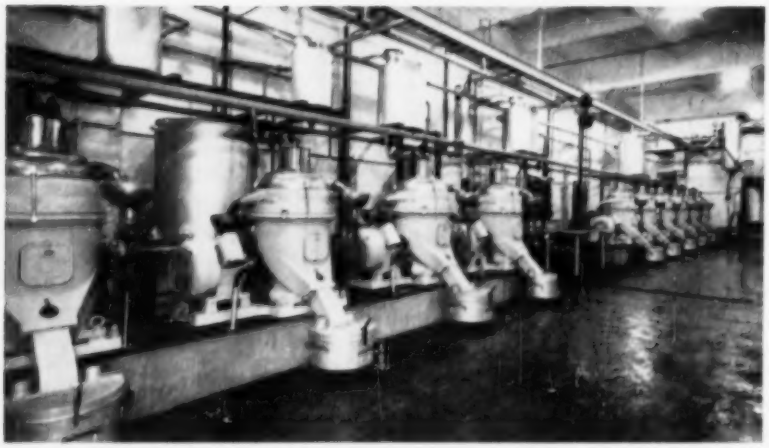
Corrosioneering News

Quick facts about the services and equipment available to help you reduce corrosion and processing costs.

Published by The Pfaudler Co., Rochester, N.Y., U.S.A.



In a single pass, these ten Titan No. 70 Superjectors separate animal fat, wash water, and solids.

Continuous centrifuging of slurries up to 35% solids

Titan Superjectors operate as long as a month *without shutdown for cleaning*

Now you can centrifuge *continuously*—eliminating costly, time-consuming clean-outs—with Titan Superjectors.

A series of ¼" slots around the bowl circumference discharge solids rapidly. Even with a slurry containing 35% solids, this cleaning action is completed in just 10 seconds.

The bowl's own centrifugal force builds up the hydrostatic pressure which opens the slots.

You can control this action manually or set it for automatic operation at prescribed intervals.

Concentrate solids up to 40%

Because the openings of the Titan's desludging *slots* are larger than those on nozzle-type centrifuges, much drier solids can be obtained. You can concentrate solids to as low as 40% moisture content and also produce much clearer effluents at the same time.

The Titan Superjector handles mixed solid sizes up to ⅛" diameter. It removes solids either heavier or lighter than infeed.

Settling vanes within the Superjector curtail turbulence and shear of solids. You can adapt infeed holes and disc spacers closely to your product by selecting from the wide range of discs available.

Some typical installations

The following list gives some idea of the wide range of installations in which the Titan Superjector has proved its value:

Separating liquids from animal intestines for pharmaceuticals.

Refining vegetable oils.

Purifying waste lubricating oils.

Extracting fish oils.

Recovery of yeast and cereal proteins.

Lower running cost, other features

Since there is no braking effect from the continuous discharge of solids in the Titan Superjector, its power consumption is exceptionally low.

And, because many of its parts are interchangeable, you can convert the Titan to a variety of services at relatively low cost.

You can eliminate foaming, aeration, and gas loss by having the Superjector hermetically sealed and discharging fluids under pressure.

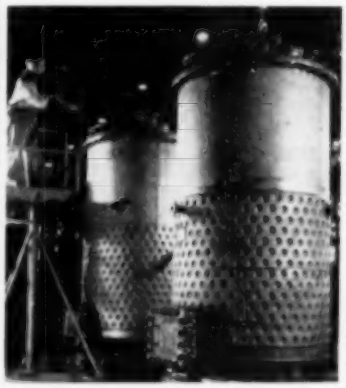
For further information, write for Bulletin 930.

Herculoy added to Pfaudler arsenal of materials to combat corrosion

You can now specify Herculoy, a silicon-bronze alloy "A," when you purchase Pfaudler equipment.

This latest addition to the Pfaudler list of fabrication materials gives you all the corrosion resistance of copper with the tensile strength of mild steel.

Highly recommended for marine service, Herculoy is readily applicable to all oxidizing environments.

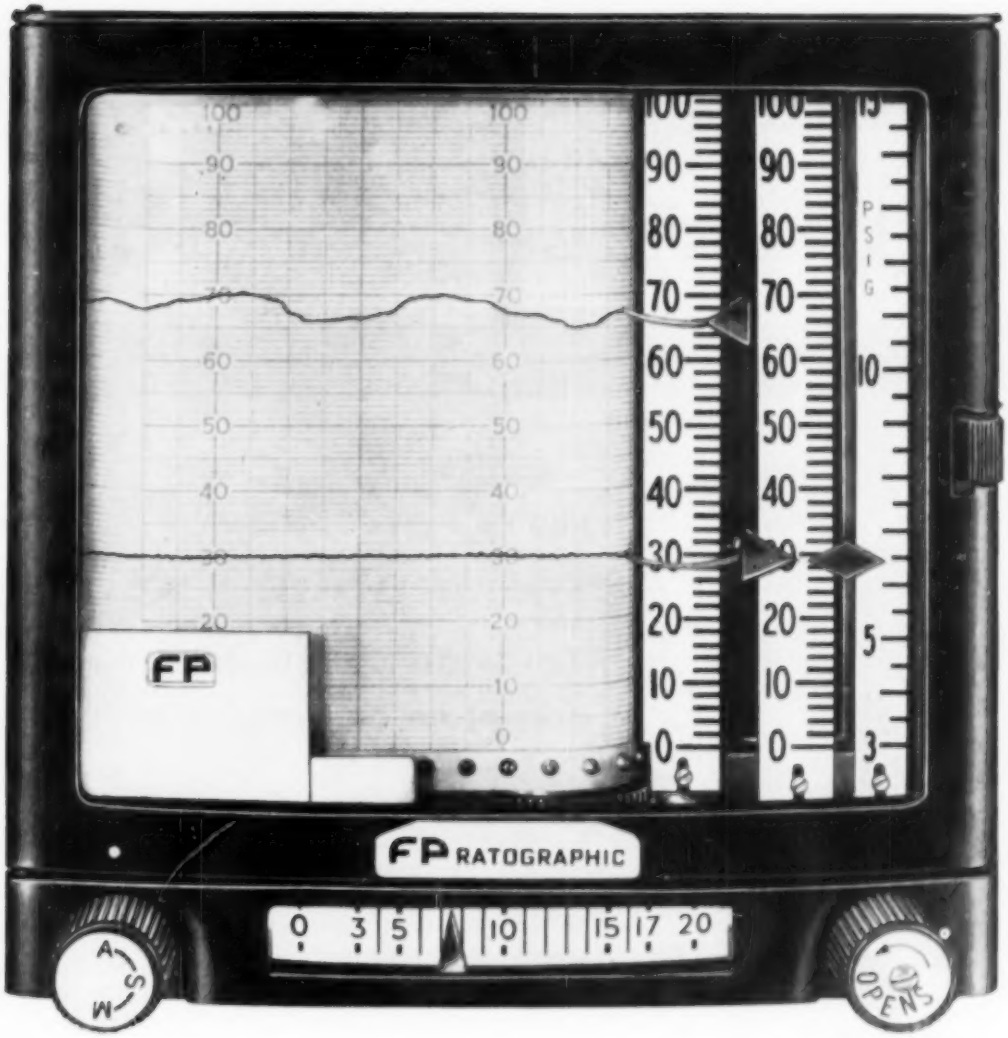


The first all-Herculoy vessels fabricated by Pfaudler in which "dimpled" jacket construction was employed.

The vessels shown above are each 970-gallon capacity and constructed throughout of Herculoy #420. Service requirements called for a 150 psi jacket pressure with a 10 psi internal pressure at a maximum operating temperature of 239° F. Stress relief at approximately 850° F. followed by air cooling was employed to further the corrosion resistance of these Herculoy vessels.

Of further significance, these vessels employed the unique Pfaudler "dimpled" jacket construction. The "dimpled" jacket design permits higher pressures than conventional jacket designs without any increase in wall thickness.

Whether your material specifications call for Herculoy, Everdur, titanium, copper, nickel, Inconel, clad materials, *stainless steel*, or *glassed steel*, Pfaudler technical skills and facilities are ready to work for you.



Fischer & Porter has the answer...it's ***READABILITY***

Look at the actual size illustration above. Notice how horizontal chart travel assures quick, easy readability. Side writing pens mean accurate reading of chart record. The entire instrument may be withdrawn from case, making visible a 14 hour chart section, *without interrupting operation of the recorder or controller in any way*. There are no other instruments like these using full four inch charts.

F&P Ratographic Recorders may be quickly interchanged from the *front* of the panel. Servicing is simple. Automatic seal-off. Consider the continuous chart rewind with handy daily tear-off. Consider the removable pens, fed from an adequate ink supply reservoir. Yes, consider *all* the F&P Ratographic advantages and you'll buy no others.

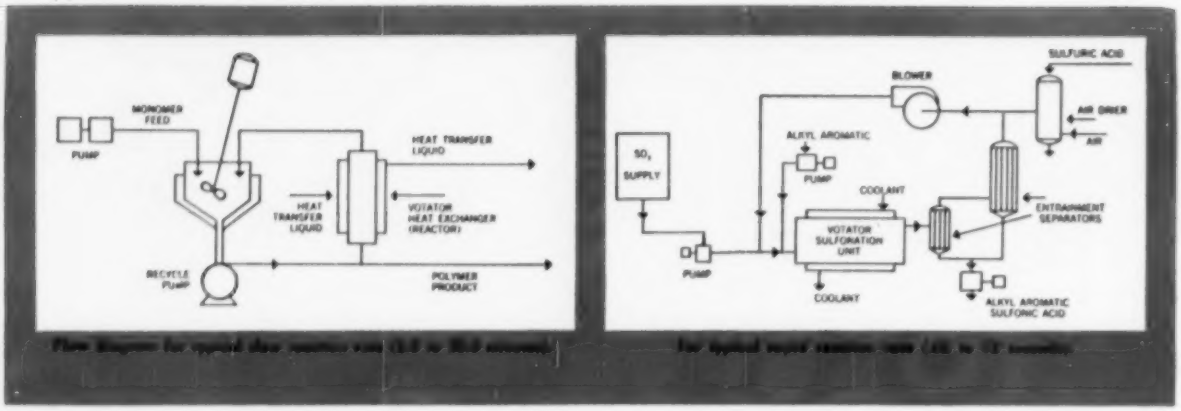
These instruments mount readily on conventional or graphic panels. Specify any of many options and F&P has the answer. A single F&P Ratographic Recorder in use will convince you of their versatility, high accuracy and dependability. That's a firm assurance. Write today for complete information or specific quotations. Fischer & Porter Co., 1147 County Line Road, Hatboro, Penna.

Illustrated Literature on Request

Catalog 55-20 is a complete, detailed report on the multiple applications, the many options available in F&P Ratographic instruments. Write for it today. No obligation, of course.

FP FISCHER & PORTER CO. Hatboro, Pa.

COMPLETE PROCESS INSTRUMENTATION



VOTATOR Continuous Reactor for sulfonation.

HOW Votator® CONTINUOUS REACTORS

provide rigid heat control and complete dispersion of reactants

OPERATION. VOTATOR* Continuous Reactors combine multiport injection system with scraped surface heat exchange. This permits handling of those reactions which evolve large quantities of heat, and those end products which are very viscous or result in a reaction product which fouls conventional heat exchange surfaces.

APPLICATIONS include sulfonation, sulfation, nitration, polymerization, saponification, neutralization, condensation, oxidation. Typical flow charts are shown above.

ADVANTAGES. Permits precise control of heat of reaction and improved processing of heat-sensitive materials. Conducts reactions continuously without excessive pressure drops. Immiscible reactants are maintained in finely dispersed state. Variables controlled automatically. Operation is safe, clean. Output is high. Costs are low. Saves floor space.

COMPLETE DETAILS

Bulletin V250 gives complete information — applications, operation, advantages, specifications of VOTATOR Continuous Reactors. Free on request.

* VOTATOR – Trade-Mark Reg. U. S. Pat. Off.

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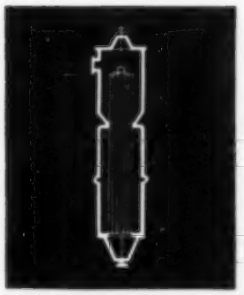
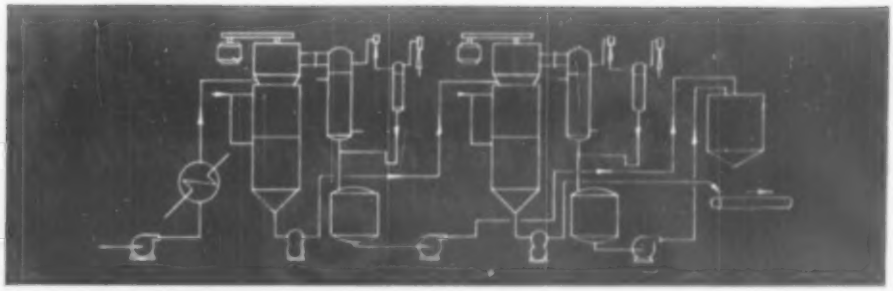
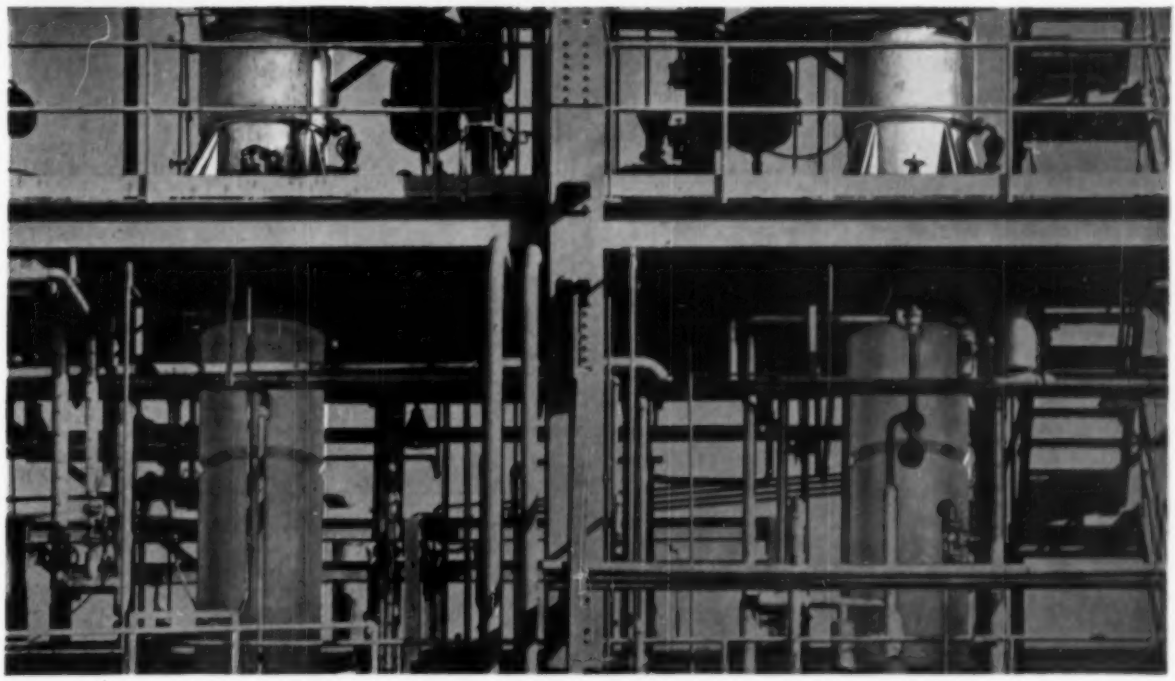






Turba-Film Processor produces epoxy compounds at Shell

The chemical and processing industries recognize that good engineering is just as important as good equipment. In recent years, Rodney Hunt has accumulated broad experience in specialized applications of the Turba-Film® Processor as well as in completely engineered package systems.

Shell Chemical Corporation produces petroleum-based resins at its plant near Houston, Texas. The process involves removal of the solvent carrier to give a dry epoxy compound. Rodney Hunt engineers proved the patented Turba-Film Processor ideal for this application. The Turba-Film permits a high degree of solvent removal with greater through-put than conventional equipment. Solvent and carrier pass through two Turba-Film units as a thin, falling film. Localized overheating is eliminated and product color is greatly improved.

Are you concerned with deaeration, deodorization, esterification, concentration, stripping, distillation, evaporation or other processing operations? Chances are good that Rodney Hunt can give you profitable answers to your problems.

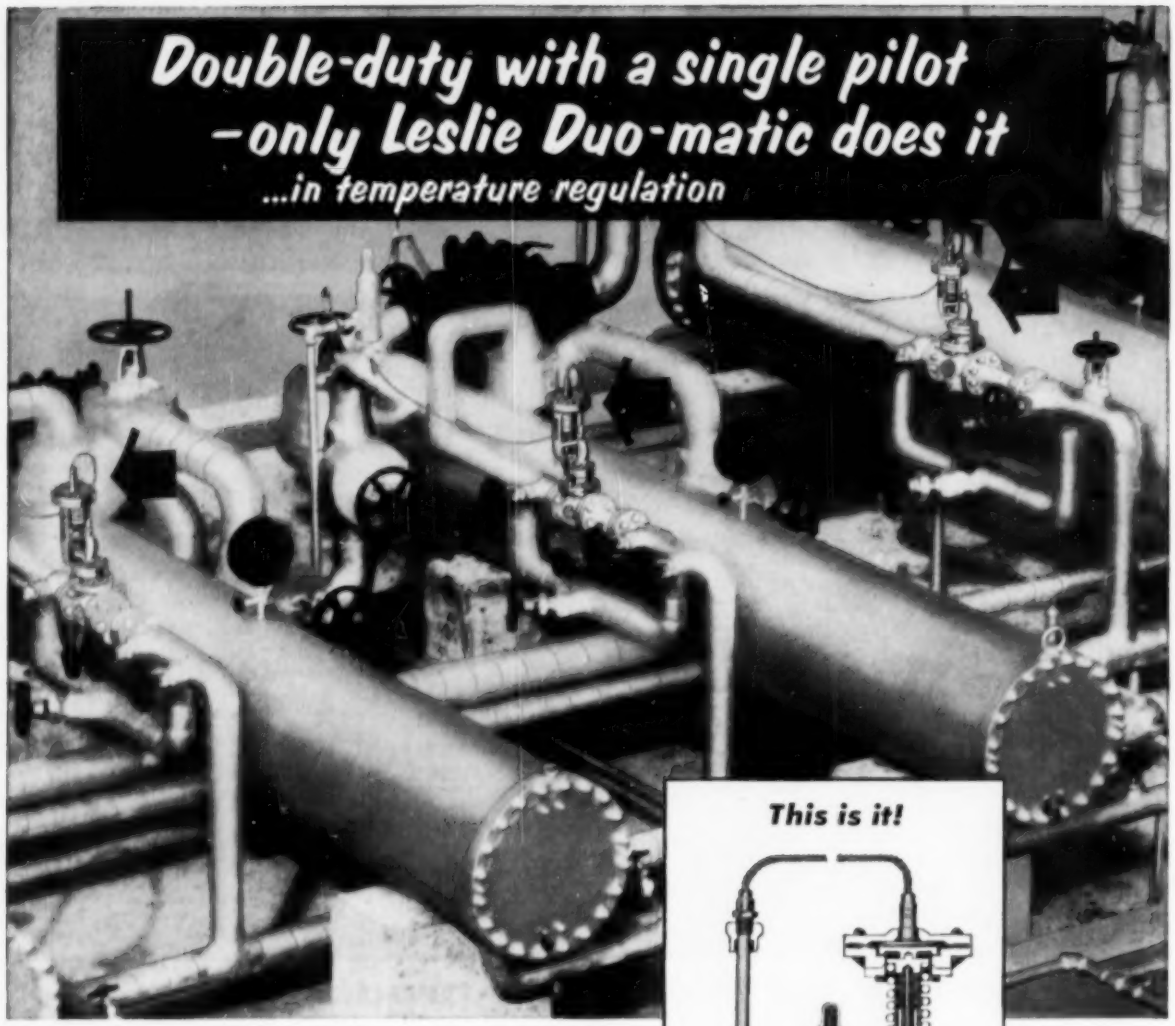
RODNEY HUNT MACHINE CO.
Process Equipment Division
37 Vale Street, Orange, Massachusetts, U. S. A.

RODNEY HUNT®

SERVING THE CHEMICAL AND ENGINEERING INDUSTRY WITH EQUIPMENT AND ENGINEERING

Double-duty with a single pilot —only Leslie Duo-matic does it

...in temperature regulation

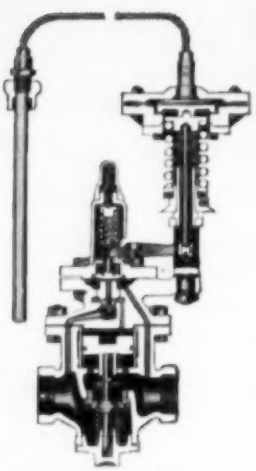


The Duo-matic Leslie temperature regulator for controlling steam flow is a single unit, with a *single* internal pilot valve—yet it controls automatically both temperature and pressure conditions. No hunting or cycling on low flows . . . eliminates temperature "droop" on heavy loads.

Simplified piping and better control of fuel oil heaters, instantaneous and storage type heaters, driers, process heaters, kettles, open tanks, ovens, degreasing machines, steam tables, sterilizers, etc., more than offset the initial cost of this superior regulator.

Investigate "dual-function" Duo-matic regulators — proven in service for over 19 years of applications.

This is it!



Leslie Class LTCO Duo-matic temperature and pressure regulator

Write for Bulletin 5307

TRADE LESLIE MARK

REGULATORS AND CONTROLLERS

LESLIE CO., 241 GRANT AVENUE, LYNDHURST, NEW JERSEY

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U.S.I. CHEMICAL NEWS

April ★ A Series for Chemists and Executives of the Solvents and Chemical Consuming Industries ★ 1957

Cabot Plans Silicon Dioxide Unit to Integrate With U.S.I.'s Tuscola Plants

Cabot Carbon Company, a subsidiary of Godfrey L. Cabot, Inc., Boston, Mass., has announced plans to build a silicon dioxide plant at Tuscola, Illinois. It will be located near U.S.I.'s ammonia plant and the ethyl chloride facility of National Petro-Chemicals Corporation (subsidiary of U.S.I.), and it will take advantage of raw materials supplied by these plants.

Raw materials used in the production of Cabot's finely divided silicon dioxide Cab-O-Sil* are silicon carbide, chlorine and hydrogen. The process used is a vapor-phase hydrolysis of silicon tetrachloride in a hot gaseous environment. This process utilizes hydrogen given off at Petro's ethylene cracker and purified in U.S.I.'s ammonia plant. In addition, Cabot will get steam and water from Petro.

MORE

Water-Alcohol Injection To Turbo-Jet Engine Cuts Aircraft Take-Off Distance

The water-alcohol injection technique, now used in the J47 gas turbine engines which power the B-47 bombers, has good possibilities in commercial jet aircraft design. It is reported to cut ground run distance and to be the most satisfactory way to increase overloaded safety on short fields. And it may be the answer to high-altitude field take-offs of commercial transports on hot days.

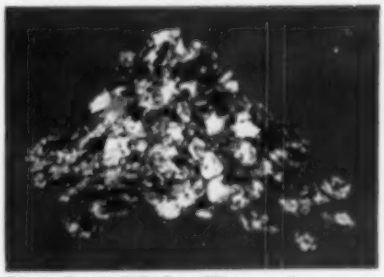
When injected into the combustion chamber of a turbo-jet engine, water is vaporized to steam which expands and increases the thrust. 28% alcohol is added to burn and so neutralize the cooling effect of the water. The B-47 bombers operate on 650 pounds per second of the water-alcohol mixture. They get about 22% increase in thrust, and 2,000 feet are cut from their ground run distance.

Chemical Buyers Get Tips On Raising Company Profits

Suggestions on how to increase company profits by making full use of vendor services were heard by the Chemical and Allied Buyers Group of the National Association of Purchasing Agents at their annual midwinter conferences held in New York and Chicago during January of this year.

In panel discussions, many specific vendor services were mentioned as being money savers for the chemical buyer's company. Among them: research and statistical data procurement, package development, raw material analysis, preparing detailed shop drawings from general specifications and sketches, special inventory stocking, consolidation of shipments and billings, specially tailored materials handling units, and employee training programs.

Keynoter for these panels emphasized use of a vendor's technical personnel and research facilities in solving mutual problems.



U.S.I. to Make Zirconium as Non-Pyrophoric Platelets

Production Plan Expanded To 2,000,000 Lbs. a Year

Reactor and commercial-grade zirconium, in the unique form of non-pyrophoric, non-hygroscopic platelets rather than sponge, will be supplied to government and industry from the U.S.I. zirconium plant at Ashtabula, Ohio, scheduled to come onstream in the second quarter of this year.

Platelets—irregular flake-like pieces about the size of dimes and quarters—insure greater safety during handling and shipping. Since they are classified as metal rather than as metal sponge, they are subject to none of the restrictions applied when the sponge form is handled. For safety reasons, the Interstate Commerce Commission requires that sponge be shipped in metal drums containing not more than 75 pounds, and that the sponge be contained in polyethylene bags and blanketed by argon gas. None of these restrictions apply to platelets.

Zirconium platelets can be compacted for melting as easily as sponge and with virtually no waste. They are of extremely high purity, being almost completely free of sodium, magnesium, chlorides, hydrogen and moisture. Freedom from impurities provides for a much cleaner melting operation for the user.

MORE

Polyethylene Resins Are Now Being Foamed

Polyethylene can now be obtained from processors as an expanded, closed-cell, flexible foam in extruded and molded forms. The cells are small and uniform and contain a harmless, inert gas.

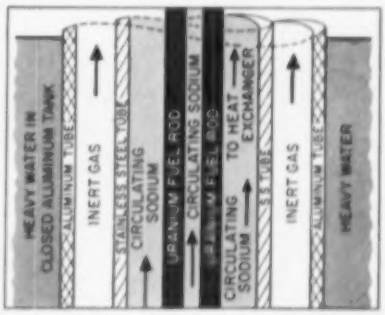
Indications are that the foamed material retains all the basic, desirable properties of polyethylene—its flexibility, toughness, chemical resistance and moisture resistance. The foam won't flake or dust. It is being evaluated for gaskets, cap and closure linings, insulation, shock absorbers, packaging, buoys and life floats, and for radiation shielding.

Foam density can be varied from 10 to 50 pounds per cubic foot. As density goes up, tensile strength and load recovery increase and deformation decreases. To date polyethylene foam has been fabricated with common wood and metal working tools, and has been drilled, machined, sawed, hot gas welded and friction and heat sealed.

First Sodium-Deuterium Reactor Authorized by AEC

Long considered almost ideal by nuclear experts, a sodium-deuterium power reactor has been authorized by the AEC. It is planned for construction at Anchorage, Alaska in 1962, and is being developed by Nuclear Development Corporation of America. The proposed reactor will use heavy water as moderator, liquid sodium as coolant and slightly enriched uranium as fuel.

The reactor will consist of an aluminum tank filled with heavy water, tightly sealed except for a closed-cycle fuel system passing through the tank. The fuel system consists in part of a number of fuel tubes, each tube being made up of two concentric pipes. Sodium flows through the inner pipe past uranium fuel rods, picking up the heat created by the fuel rods and transferring it to a heat exchange system. An inert gas under pressure flows through the outer pipe. This gas serves to insulate the inner pipe and will be at a pressure higher than that of the water or sodium, minimizing the possibility of contact should a leak develop.



Cross-section of one fuel tube passing through sealed aluminum tank filled with heavy water. Tube consists of two concentric pipes. Inner pipe contains uranium and sodium. Outer pipe contains inert gas.

Advantages claimed for this system include: operation on low-enriched fuel; long fuel lifetime; more complete burnup of U-235 and the plutonium produced; delivery of heat at very high temperatures without high pressures; low pressure for entire reactor system, eliminating need for expensive pressure vessel; absorption by moderator of fewer neutrons than light water or graphite; suitability over wide range of power levels without radical design changes.

Argon Grade Sodium Frequently Used

Liquid sodium is used as a coolant in two other types of nuclear energy systems—the sodium-graphite and fast-breeder reactors. One fast-breeder now under construction will use U.S.I.'s Argon Grade Sodium as coolant material.

This grade of the metal is carefully filtered free of oxide to avoid corrosion in lines and other parts of the heat transfer system. It is processed and packed under a blanket of inert argon gas to maintain the oxide-free condition.

April ★ **U.S.I. CHEMICAL NEWS** ★ 1957

CONTINUED *Zirconium*

Production Goal Expanded

Originally scheduled to produce 1,500,000 pounds a year, the plant is now slated to turn out 2,000,000 pounds annually. Under a contract signed on May 1, 1956, 83,000 pounds a month are committed to the Atomic Energy Commission. An equal amount will be offered to industrial users.

U.S.I. is now quoting prices of $4.75 to $6.50 per pound, depending on quantity, for its hafnium-free zirconium platelets as compared with the present price of $12.00 per pound for sponge. This is due to U.S.I.'s economical sodium process—the first semi-continuous process for making zirconium—which requires a lower initial investment than the conventional magnesium process.

Commercial zirconium which is not hafnium-free and which is suitable for non-nuclear uses will sell for about a dollar and a half less per pound.

Industry Will Get Hafnium

The forthcoming plant will also have 20,000 pounds of hafnium as hafnium oxide or sponge available for industrial use. Hafnium, an excellent neutron absorber, is employed in atomic reactors as a control rod material.

Amino Acid Deficiencies Cause Damage to Nervous System and Vital Organs

According to recent laboratory studies on experimental animals, serious disturbances in the higher nervous system, as evidenced by lower reflex action, can be caused by deficiencies in lysine and methionine. Degeneration of the liver, pancreas and kidneys may also result.

Five weeks on a balanced diet restored the activity of the organs affected, but part of the reflex damage appeared to be permanent.

CONTINUED *Silicon Dioxide*

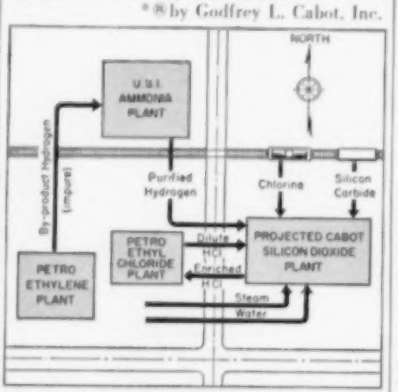
Petro Uses By-Product HCl

By-product hydrochloric acid from Cabot's new plant will be used in National Petro-Chemicals' ethyl chloride plant. A stream of hydrochloric acid will circulate between Petro's ethyl chloride facility and Cabot. By-product hydrogen chloride from Cabot's new plant will enrich the circulating stream, and will be removed at Petro for use as a raw material in the ethyl chloride unit. Hydrogen chloride for this unit is currently being made by burning hydrogen with chlorine.

Unit Produces "White Carbon Black"

Cab-O-Sil silicon dioxide—a white pigment frequently called "white carbon black"—is now produced for Cabot in Germany, but increasing demand has made an American plant necessary. The new unit will have an initial capacity of about 100 carloads per year. The product is claimed to surpass the precipitated type synthetic silicas for reinforcing plastics and rubbers, as a suspending agent in paints, a flatting agent in varnish, a gelling agent in lubricants, an anti-slip agent in wax and in the insulation of electrical equipment and many other fields.

*®by Godfrey L. Cabot, Inc.



Flowsheet showing interrelation of Petro, U.S.I. and Cabot plants at Tuscola, Illinois.

TECHNICAL DEVELOPMENTS

Information about manufacturers of these items may be obtained by writing the Editor, U.S.I. Chemical News.

Formulation for a witch hazel foam shave cream is now being offered by manufacturer. Witch hazel distillate is claimed to lend refreshing cleansing and soothing qualities to this new aerosol foam shave cream formulation. **(No. 1220)**

Four new antistatic agents for polyethylene are reported to destaticize permanently. A half to one per cent is incorporated into polyethylene pellets or powder before extrusion or molding. Used on high and low pressure resins. **(No. 1221)**

Portable paper laminator which can be used to preserve documents is described in a recent pamphlet accompanied by a price sheet which is itself covered with the preserving film. **(No. 1222)**

To fireproof fabrics right in the home, a powdered anti-flame agent has been developed which is non-toxic and does not harm the appearance, hand or comfort of the fabric. Used as a rinse after the regular wash, it must be reapplied after each laundering. **(No. 1223)**

New marking ink for plastics and other hard surfaces uses pigments to get highly opaque colors. Is claimed non-corrosive, non-etching, fast-drying and with excellent adhesion. Wears well and resists water, many solvents. **(No. 1224)**

The flavoring of pharmaceuticals is discussed in a new catalog which gives for the first time a truly comprehensive list of materials developed for or adapted to this purpose. Guide is carefully indexed and cross-referenced. **(No. 1225)**

Induction furnaces for analyzing hydrogen in titanium and zirconium can now be obtained, reported to handle samples up to 10 grams in solid, drilling or chip form. Sample is burned in oxygen and resulting water is weighed. **(No. 1226)**

Sterile polyethylene bags are used to pack petri dishes containing ready-to-streak culture media. Now available in this pack are nine different culture media used in routine bacteriology and mycology. **(No. 1227)**

New unit for operating laboratory water baths combines in one piece of apparatus a self-contained heater, controller, stirrer and circulator with a built-in pneumatic control system claimed sensitive within ±0.05°C. **(No. 1228)**

New dry film lubricant for drawing and forming titanium and its alloys, chromium and stainless steels at 600-1400°F has been formulated. Consists of fine graphite plus high-temperature binder dispersed in aromatic solvents. **(No. 1229)**

PRODUCTS OF U.S.I.

INORGANIC CHEMICALS:

Sodium, Metallic: cast solid in tank cars, steel drums, pails, bricks in barrels, pails.
Chlorine: liquid, in tank cars.
Caustic Soda: 50% liquid, in tank cars.
Sodium Peroxide: dust-free granules, in drums.
Sodium Sulfate
Sulfuric Acid: all strengths, 60° Baumé to 40% Oleum. Also Electrolytic grade to Federal specifications. Tank cars or tank wagons.
Phosphoric Acid
Ammonia: Anhydrous, commercial and refrigeration. Tank cars or tank wagons.
Nitrogen Fertilizer Solutions
Ammonium Nitrate: 83%

OTHER PRODUCTS:

Alcohols: Ethyl (pure and all denatured formulas), Normal Butyl, Amyl, Fusel Oil, Proprietary Denatured Alcohol Solvents SOLOX®, FILMEX®, ANSOL® M, ANSOL® PR.

PETROTHENE® Polyethylene Resins.
Esters, Ethers and Ketones: Normal Butyl Acetate, Dibutyl Phthalate, Diethyl Carbonate, Diethyl Oxalate, Ethyl Acetate, Ethyl Ether, Acetone, Diatol®.
Intermediates and Fine Chemicals: Acetoacetarylides, Dimethyl Hydrazine, Ethyl Acetoacetate, Ethyl Benzoylacetate, Ethyl Chloroformate, Ethylene, Ethyl Chloride, Ethyl Sodium Oxalacetate, U.S.I. ISOSEBACIC® Acid, Methyl Hydrazine, Sodium Ethylate Solution, Triethyl Aluminum, Trimethyl Aluminum, Urethan USP (Ethyl Carbamate).
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the care and feeding of the creative center — THE INNOVATOR

O. A. Ohmann * | The Standard Oil Company (Ohio), Cleveland, Ohio

Can Large Organizations Produce Innovation?

Significant advances in our material standard of living have usually been triggered by some major scientific or technological innovation. Most of our great American enterprises were built on the adaptation and economic exploitation of such new ideas. Typically these enterprises can be traced to the creative genius of a single individual in whom inventor and entrepreneur were combined, or perhaps to a partnership of two such creative talents. The industrial organization which then developed was merely the means of implementing such a center of technological and economic creativity. The organization was an extension of these ideas; a servant of them; a product of the ideas rather than a producer of them. The creative center continued as a fluid, unorganized dynamism, regardless of the rigidities that might develop at the periphery of the organization.

It seems clear that future increases in productivity will continue to depend primarily on such combinations of technological, economic, and perhaps administrative or managerial innovation. However, as industrial organizations grow in size they become more formally structured, more standardized in their operations, and more time and energy will necessarily be devoted to the coordination, maintenance, and service of the organization itself. Resultant power centers and the rigidities established to support them are natural enemies of the creative spirit.

Size itself puts a premium on administrative skills and thus the managerial function tends to gravitate from the innovators to the coordinators. It seems pertinent, therefore, to ask whether we can accomplish the magic of a reversal. Can the big corporation which developed as the servant of a creative center now become the creator of *true innovation* and *new* enterprise? And more specifically, how? (These questions are particularly pertinent in view of the higher percentage of total manpower employed in large-scale enterprise, and also because the order or magnitude of innovation in the future may require dollars, facilities, and time on a scale which the individual enterpriser will not be able to supply.)

The recognized genius of big business has been its productive efficiency and its capacity to generate capital for further expansion and enterprise. In achieving these objectives, management has developed great skill in coordination and execution, and through research and engineering has continually improved, adapted, perfected and extended its services and products. When it comes to true innovation, however, the record of the big corporation is not impressive. It is reported, for example, that of all the household appliances, the garbage disposal unit is the only one invented by the large appliance manufacturers. This is not the place to rack up the score, but there is considerable evidence to show that the really significant "breakthroughs" have occurred outside the large corporations. Big companies have frequently furnished a market for the ideas of these little people, and have made important contributions to the further development, engineering, and exploitation of such innovations. It is not uncommon for such small creative centers to operate as satellites of the corporation, perhaps even subsidized in some manner by it. That the large industrial organization can itself create major innovation still remains to be proved.

The Nature of Creativity

To understand what needs to be done to promote creativity in the industrial organization, it will be helpful to clarify our conception of the characteristics and mode of operation of the innovator, and perhaps contrast him with what has recently been described as "the organization man."

Someone has said that there are two kinds of people: those who classify people into two types, and all others. Recognizing that all such generalizations are an oversimplification of the facts, it may nevertheless be helpful at this intuitive stage of our thinking to point up some important differences between certain typical administrators and the rather typical innovator. (This account admittedly pictures the extremes and grants that degrees and mixtures are possible.)

The *administrator* is orderly, likes to move systematically and according to plan. He takes delight in a precisely coordinated operation. Essentially a technician, he likes to improve and perfect rather than to strike out in uncharted directions. He is more of a professional who takes pride in his art rather than a gambler who is willing to take risks on a hunch. He prides himself on being practical and realistic. He thinks in terms of adjusting to his environment. He has a strong interest in people and in coordinating their efforts. He is a coach who takes pride in developing a championship team, has faith in his people and has great patience, yet pushes quietly for results. He keeps his objectives in mind and moves toward them calmly, steadily, confidently, administers by laying a groundwork of policies and standard procedures. He is well disciplined and controlled.

In contrast, the *innovator* (somewhat regardless of field of activity) is mentally restless, roving, inquiring,

* Mr. Ohmann is Director of Organization Planning and Management Development.

CREATIVITY

(Continued from page 21)

unorthodox, unpredictable, uncontained. Essentially he rejects his environment and the answers it presents. He is sensitive to problems and raises many questions. His interests are many-sided, but he is not a hobbyist or a putterer. He thinks in terms of ends or goals rather than procedures. He perceives in terms of incomplete wholes and unresolved problems. Being goal-oriented, he develops almost obsessive motivation, in fact, a sense of mission. The goal becomes an overriding passion which makes him impatient with red tape or people or anything that impedes the solution. Being oriented to problems rather than to people, he is typically a solitary, unsociable worker, yet at certain stages he may want and need to discuss his ideas with others whose abilities he respects. He is frequently most effective as the nucleus of a small informal task force. Being obsessed by his goal, he loses interest quickly when the solution has been conceived and is weak on working out the details and following through. His intense drive burns up tremendous physical and mental energy. He is not much interested in the usual rewards, incentives and prestige symbols. He displays a strong, almost mystical sense of individual mission and feels that he has a special role in the cosmic scheme. He is risk-minded and willing to gamble all on the chance of a discovery. He is frequently unorthodox in social life, insensitive to social conventions, not particularly happy and well adjusted, yet views life as an exciting adventure.

From this thumbnail sketch it will be obvious that these "organizational screwballs" are not easily digested into a functioning business operation. This in a sense points up the requirements for preserving creative centers in an organization; namely, the recognition, toleration, and cultivation of such individualists.

We should recognize that within every scientific and professional association there are present potent and silent pressures to force conventional thinking. Scientists and engineers are educated in a uniform factual and methodological background. Fear of criticism from members of the guild is a very real leveler of ideation. What chemical engineer would dare to publish in his favored trade journal a purely intuitive piece of speculation without the usual supportive evidence? American science is essentially conventional and orthodox and its record of innovation compares unfavorably with that of many European countries. Scientific dogmas may become more tyrannical than theological dogmas ever were.

—O. A. Ohmann

Blocks to Creativity

By philosophy, tradition, and administrative practice the large industrial organization presents a number of natural blocks to creativity. A brief review of some of these may throw additional light on what is needed to keep these centers alive.

1. The industrial organization is essentially authoritarian in design and operation. The emphasis is on getting things done and conducting the necessary operations, rather than on creating and dreaming. The forms, philosophy, concepts, and practices of business organization have been largely borrowed from the military and throughout, uniformity and discipline take precedence over creativity.

2. Mass production is based on standardization and the inflexible repetition of carefully prescribed operating procedures. Some studies in the I.B.M. organization indicate that the development of managerial talent is definitely retarded in those departments and units of the company which are highly organized and overformalized. Individuality is lost when the climate stresses uniformity, and creativity gives way to security.

3. The principle of specialization of function and the practice of structuring organization around each of these segmented functions make it difficult to visualize and understand the *whole* job. Creativity, however, is by nature integrative and seeks significant relationships. In such specialized organizations innovations are usually limited in scope and more in the nature of small improvements, adaptations, or extensions of knowledge—not likely to result in new enterprises.

4. The line and staff form of organization usually leads to an unfortunate separation of the research and analytical functions from the "doing" or operating activities. The lack of integration of staff with line, if not in fact the open conflict between them, is keenly sensed by nearly all staff workers. In some instances creativity thus operates in an unrealistic vacuum.

5. Bigness per se militates against creativity because it reduces the individual's sense of personal responsibility. It is easier to achieve a sense of individual responsibility in a company with 10 to 100 employees than in one with 25,000. Also, job security and benefit programs provided by most big companies reduce considerably the burning necessity to create.

6. The inbred culture of a company constitutes a silent but steady pressure for social conformity which further inhibits innovation. It takes real courage to insist that an idea which was tried 20 years ago and failed should now be tried again.

7. We must frankly recognize the corporation as a power structure, which tends to resist change and which is by nature not permissive and creative in its climate. Creativity in an organization is therefore more a matter of attitude than of adopting certain specific organizational forms or administrative techniques.

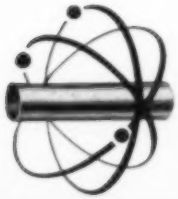
These, then, are some of the barriers to creativity which develop in large organizations regardless of the nature and purpose of the institution—business, government, unions, even the church. The bigger and stronger they get, the more they lay the seeds of smugness, rigidity, and disintegration. This, according to the historian Toynbee, has also been the recurring story of the growth and decline of 21 great civilizations—they became successful, big, rigid, unadaptable, and the little people took them over.

All this may appear to be a discouraging indictment—and not a very creative solution to the problem. However, the first step to such a solution may be the clear recognition of the nature of the difficulties. It is in fact the recognition of these barriers by business managers which has already set the wheels of ingenuity and experimentation in motion.

What Can Be Done?

A number of methods which have already been tried in industry perhaps suggest some other possible approaches to keeping the vital creative centers alive. The nature of the difficulties will vary from one company or department to another and the approach to the problem will also vary. A creative solution must be sought in each situation.

1. More and more companies are



About the
NUCLEAR PRODUCTS DIVISION OF SUPERIOR TUBE

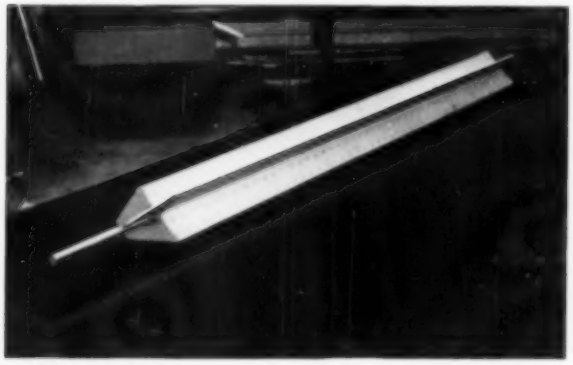
For design and construction of intricate reactor components of special types

PEOPLE

This division offers the atomic industry the teamwork of a wide variety of highly skilled personnel, including mechanical, metallurgical and welding engineers, fully qualified to assist in developing Classified and commercial projects. They are supported by expert inspectors and quality control people who insure close adherence to all specifications.

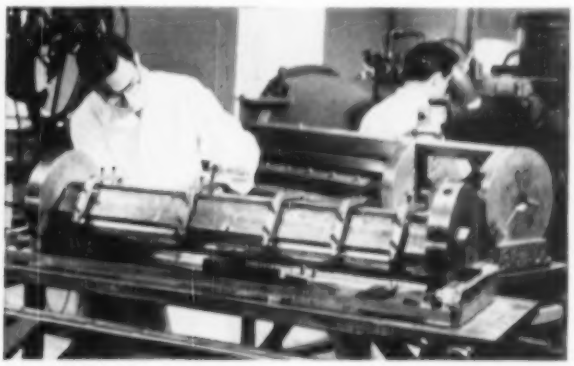
TOOLS

Equipment includes a modern vacuum welding chamber; a variety of hydraulic presses; facilities for atmosphere, vacuum furnace and salt-bath heat treating; swaging machines; high pressure-and-temperature autoclaves for corrosion testing; pickling and rinsing baths; milling, turning, shaping and planing machines; and modern final inspection equipment.



KNOW-HOW

Among the many products being turned out by this division are specially shaped control rod channels, assembly channels, and control rods; also reactor components produced from sheet, bar and plate in squares, hexagons, rectangles or rhombuses, all produced to very close tolerances. The Nuclear Products Division is currently serving many of the key manufacturers in the atomic energy field.



SERVICES

These include help in the design of reactor components; design and construction of intricate tools and fixtures to fabricate reactor components; development of manufacturing facilities after the prototype has been fabricated. Many materials are utilized, including the reactive metals—titanium, zirconium and their alloys. We also supply tubing for many atomic applications.

For information on our Nuclear Products Division or tubing for atomic power, write Superior Tube Company, 2011 Germantown Ave., Norristown, Pa.

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CREATIVITY

(Continued from page 22)

now providing within their organization structure a unit reporting to the chief executive and devoted entirely to economic studies, enterprise research, and long-range planning for the company. These departmental units can furnish integration and perspective to creative study groups at lower levels in the organization and also provide a channel for the upward communication of new ideas and proposals which require consideration at higher levels.

2. A close integration of staff activities with line operating responsibilities has in some instances been accomplished through a clearer definition of annual specific objectives for the department and for each of its principal units, with staff heads participating in the discussions which led to the establishment of objectives for the line units.

3. The use of special task forces and research teams is one way of counteracting the effects of specialization and insures cross-fertilization of ideas between departments. Such teams should be kept fairly small, should be composed of individuals who respect each other's capabilities, and should revolve about one really creative *individual*, who may or may not be the official leader of the task force.

4. Reorganization and augmentation of the office force frees the professional man of all possible papers and routine chores. Reporting procedures can also be streamlined.

5. Improvement in the effectiveness of creative centers can be gained by giving them better orientation and broader perspective on the projects to which they have been assigned. These creative groups should also be involved in the evaluation of projects and the preparation of the budget.

6. Results with formal instruction on creativity have not been uniformly rewarding, but payout has been achieved in some instances with "brainstorming" techniques, principally in loosening up an overly formalized and rigid work environment. Training can also be achieved through careful job rotation.

7. Perhaps the recipe for rabbit stew should also state that one must first catch the rabbit. Innovation revolves about a limited number of highly creative individuals who must be recognized, given favorable working climate, and protected against all of the natural pruning which takes place in an organization.

8. Adequate compensation should be provided for innovators so that they need not seek promotion into supervisory jobs in order to advance financially.

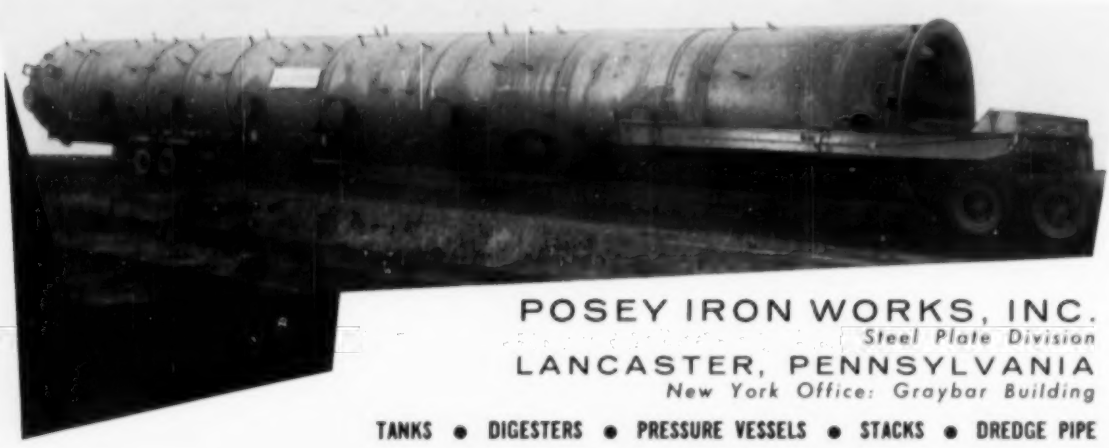
9. Although the main stream of innovation in most large research organizations can be traced to a relatively small number of individuals, it should be noted that the forward push of a company also depends on the sense of responsibility and ingenuity of every employee in the organization. Every member of an organization represents the potentiality of making a unique contribution to the particular operations with which he deals—provided the structure of the job and its environmental setting are favorable.

In the final analysis the principal thing that can be done by an organization to promote creativity is to develop a climate which is favorable to new ideas. Some have described this as a *listening* attitude on the part of management. Others achieve it through the practice of participative management. In any case, it rests on a feeling that the top management is genuinely interested in ideas down the line and has faith in the capacity and the concern of all individuals in the organization.

Presented at A.I.Ch.E. meeting, White Sulphur Springs, West Virginia.

POSEY TOWERS

Feed Splitters like this one . . . 98′ long by 10′ I.D., and now in service in one of the East Coast's largest plants . . . must be precision-built from beginning to end. Posey Iron has the experience, the facilities and equipment, as well as the skilled men to turn out a flawless job every time. Write for information about Posey installations in your industry. Let Posey quote on your next requirement for fabricated steel structures.



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PROCESS EQUIPMENT BRIEFS

No Limitations on Economic Design with "Karbate" Heat Exchangers

In addition to superior corrosion resistance, "Karbate" impervious graphite shell and tube heat exchangers offer striking economies in the design and operation of heat exchange systems. "Karbate" exchangers permit economically high tube velocities and consequent reduction in heat transfer surface required – resulting in lower initial equipment costs and operating expense.

A large manufacturer of organic chemicals had used low tube side velocities to prolong the life of carbon steel heat exchangers used in a corrosive monoethanolamine service. This failing, the original units were replaced with "Karbate" shell and tube heat exchangers. After 2 years service, the "Karbate" exchangers showed no effects from exposure to the carbon dioxide-rich monoethanolamine solutions. Even more significantly, the "Karbate" impervious graphite units provide the required heat exchange with less than ⅔ the effective area of the carbon steel units. For full information on "Karbate" heat exchangers request **Catalog Section S-6740.**

New "National" High-Temperature Cement

"National" Cement Grade C-6, a new product developed by National Carbon Company, now makes it possible to fabricate large and relatively complex carbon and graphite structures for high temperature service.

The cement is easily prepared for use by mixing the powder and liquid ingredients shipped in a unit package. Pot life is exceptionally long. After the carbon or graphite parts are cemented together, the cement is cured for a brief period at low temperature. The fabricated structure may then be operated at temperatures as high as 3600°F. with assurance that the cement bond will remain as strong and chemically resistant as the carbon or graphite parts of the structure.

"KARBATE" Impervious Graphite Entrainment Separators Feature Corrosion Resistance, Simplicity, High Efficiency

"Karbate" Impervious Graphite Entrainment Separators – Type MV, now stocked in low cost standard units, are an efficient, economical means for removing entrained liquids from gas streams. These units operate through a combination of venturi action and impingement. Staggered rows of specially shaped vertical impervious graphite rods are contained within an impervious graphite body. Separated liquid collects at the bottom of the rods and is removed through an impervious graphite drain connection.

Type MV Entrainment Separators contain no moving parts and are nonclogging. Streamlined rod shape retards re-entrainment and offers minimum resistance to gas flow. Because corrosive liquid and gas contact only "Karbate" Impervious Graphite, units are virtually immune to corrosion over a temperature range from −40°F. to 338°F.

Standard sizes of "Karbate" Entrainment Separators – Type MV assemble directly into 6", 8", 12", 16", 20" and 24" horizontal lines. Units are self-contained and ready to install. For complete information, request **Catalog Section S-6900.**

"Karbate" Entrainment Separator Type MV ready for installation. Self-contained and shipped ready for use, unit mounts with axis horizontal between standard flanges. Unique design provides effective separation over a wide range of gas flow rates, entrainment content and liquid droplet particle size.

"KARBATE" pumps available in wide capacity range

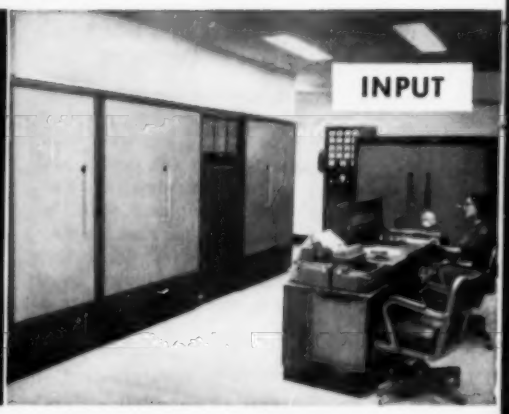
Standard "Karbate" impervious graphite pumps listed below are carried in stock for prompt shipment. These pumps are used for transfer and circulating service involving corrosives, and deliver 5 to 1500 gallons/minute at heads up to 120 feet and operating pressures up to 100 lbs./square inch. For full information, request **Catalog Section S-7250.**

Pump size			Motor-Mounted	Frame-Mounted
Suction		Discharge	Type F	Type C
2	x	1½	29-FAL	1½-CB
3	x	2	19-FAL	2-CA 2-CB
4	x	3	—	3-CA 3-CB
6	x	4	—	4-CA

The terms "Karbate" and "National", "N" and Shield Device are trade-marks of Union Carbide and Carbon Corporation

Electronic Route to

Super-Speed Computer Minimizes Heat Transfer Surface Requirements of Heat Exchangers . . .



Control section of Kellogg's computer

IN DESIGNING heat-pressure process equipment, the addition of a large magnetic drum digital computer to M. W. Kellogg's facilities enables the company's engineers to study variables and produce results with unprecedented thoroughness, accuracy, and speed. Human error is practically eliminated.

To Kellogg's customers in the petroleum and chemical industries, this new electronic aid means that Kellogg engineers can devote more time to basic design problems, and provide equipment with maximum operating efficiency, minimum maintenance costs, and the lowest possible initial investment.

In the case of heat exchangers, for example, design calculations require a trial and error solution. The time required to do this with hand calculations seldom permitted several design alternates. Thus the engineer never could be sure that the design selected was the true optimum. With high speed electronic computation, however, the greater number of alternates economically possible now brings the ultimate or near ultimate design to every Kellogg customer.

In one instance recently, involving 37 heat exchanger shells, the greater number of calculations achieved with the electronic computer resulted in reducing total heat transfer surface requirements by more than 15% from estimated values. Without the computer, the time required to obtain this value would have outweighed the saving many times, and would have been prohibitive.

Kellogg welcomes the opportunity to put its electronic computer and other engineering facilities to work for you. Arrangements to see the computer in operation in Kellogg's New York office can be made by contacting the company's Fabricated Products Division.

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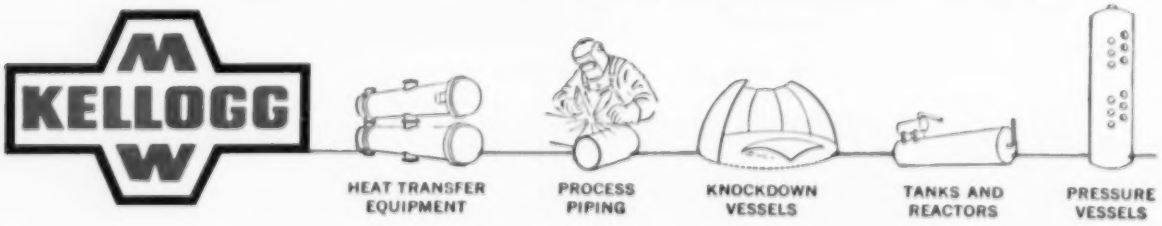


Optimum Designs

Estimate Shell Size and Arrangement

Tube Side Arrangement
Tube Passes, Critical Temperatures, Velocity

Shell Side Arrangement
Shell Passes, Baffles, Velocity, etc.

Preliminary Performance Evaluation
MTD and Heat Transfer Resistances

Final Performance Evaluation
MTD, Resistances of Each Zone and Shell

Modify Design
Parallel series arrangement
Tube Passes
Shell Passes
Shell Size

Examine Performance and Design
Reject
Accept

PRINT OUT

HEAT EXCHANGER		
ITEM NO A TYPE	75634 B	
ARRANGEMENT SERIES PARA	P A	
SURFACE TOTAL PER SHELL	6179 35240	10HR 67630
TOTAL FLUID 2000 LBS HR	145 00000	371 00000
SP GRAVITY LIQUID	87630	87630
TEMP VISCOSITY F CS A	53130 01306	53130 01706
TEMP VISCOSITY F CS B	53100 01102	53300 01805
TEMPERATURE HOT	100 00000	350 00000
TEMPERATURE COLD	120 00000	286 00000
TUBE PASSES PER SHELL	00000	8 00000
PRESS DROP ALLOW PSI	10 00000	15 00000
PRESS DROP CALCD PSI	9 96980	15 06021
FOUL RESIST & TUBE DIAMTR	00004	1 00000
DUTY MM BTU HR & MTD +TD	33 35000	87 64713
TOTAL RESIST SERVICE CALCD	01436	01163
DESIGN PRESSURE PSI	150 00000	300 00000
TUBE NUMBER AND LENGTH FT	912 42078	20 00000
SHELL ING DIAM BAFF PITCH	100	0 01250

This liquid-liquid heat exchanger design flow sheet shows the route taken by Kellogg's electronic computer to obtain optimum design results. The boxes shown at right indicate the paths taken by the machine in arriving at the solution. Photograph at right is of a partial tabulation, showing how the computer presents results.

Letters to the editor

"Do It Yourself" Oxygen

We welcome your mention of our oxygen installation at the Celanese plant at Bishop, Texas (*CEP*, December, 1956, page 52).

In the same article, your paragraph entitled "Unique System" leaves us somewhat dismayed. The concept of "on-site" oxygen generation, in the consumer's plant, was pioneered by Air Products, who had such generators on stream without capital participation by the customer at least five years ahead of the entire industry, including the oxygen supplier mentioned in the article.

Before other suppliers followed Air Products in this field, the lines of difference between "on-site generation" and "hauled-in oxygen" systems were clearly and emphatically drawn.

We make the investment, install, operate, and maintain the plant if the customer so desires. If he wishes, he may terminate Air Products' operation of the plant and assume operating responsibility himself at any time. The lease agreement has a provision whereby the customer may acquire ownership of the complete facility at the end of the lease period, a feature "unique" with Air Products.

Many major United States' producers are currently obtaining their oxygen requirements from Air Products' on-site leased generators. Some of these plants are near their twelfth anniversaries. Outstanding examples include major steel producers, glass manufacturers, automobile manufacturers, and chemical companies.

Dexter F. Baker
Sales Manager
Air Products, Incorporated
Allentown, Pa.

No So Fast on Fast Write-Offs

I feel that your comment, "The reason for the huge building of plants under fast tax write-offs was because a large part of the cost of the plants was paid for out of taxes," (*CEP*, January, 1957, page 49) contains misleading and undesirable connotations.

The principal effect of a fast tax write-off is to defer income tax payment in part until after the end of the write-off period. The total tax paid is not affected unless the tax rate changes during the period involved.

Fast write-offs were authorized by Congress to encourage the building of plants needed for national defense. The cash value of the resulting tax deferral can be expressed as the present worth of the annual cash generations with a fast write-off minus the present worth with normal write-off. If an interest rate in the range of 8 to 12 per cent is used, the present worth of a five-year write-off is equal to 10 to 15 per cent of the cost of the plant. This is a real advantage to a manufacturer who can use new plant capacity —but it is not getting a large part of the cost of a plant "paid for out of taxes."

L. R. Steffens
New York City

Noted and quoted

"NUCLEAR" ENGINEERS

(*Continued from page 8*)

supports the idea that there is a distinguishable field of "nuclear engineering" except for the most prosaic purposes of describing an engineer working on some aspect of nuclear reactors. . .

My own observation based on both AEC and industrial experience is that neither special education nor long specialized experience is needed to do an effective job even in research and development in the atomic energy field. These are helpful, in many cases, but not a necessity. The principal requirements observed in my experience are for a sound background in the basic work of science and engineering, initiative, and imagination. . . .

(As far as the engineering and scientific societies go) . . . each of the societies has an obligation to integrate the various aspects of engineering in the nuclear industry into its framework . . . it does seem to me to be a mistake to endeavor to set up the nuclear engineering aspects as something wholly separate and different from the other areas of interest of the society. I believe the American Nuclear Society fulfills an important function . . . but I do not believe this relieves the individual societies from their responsibilities or that it necessarily interferes with them. . . I hope the Nuclear Engineering Division can become fully integrated with the A.I.Ch.E. so that it serves as a focal point for the many chemical engineering aspects of the atomic energy industry. . .

There is a need for "modern engineers" who . . . must have a much better education in the sciences and in engineering fundamentals and must be able to deal with broad and complex problems . . . the problem is in the needs of this "modern engineering" not in the establishment of a new and separate engineering discipline called nuclear engineering.

Condensed from an address at Nuclear Engineering and Science Congress, Philadelphia, 1957

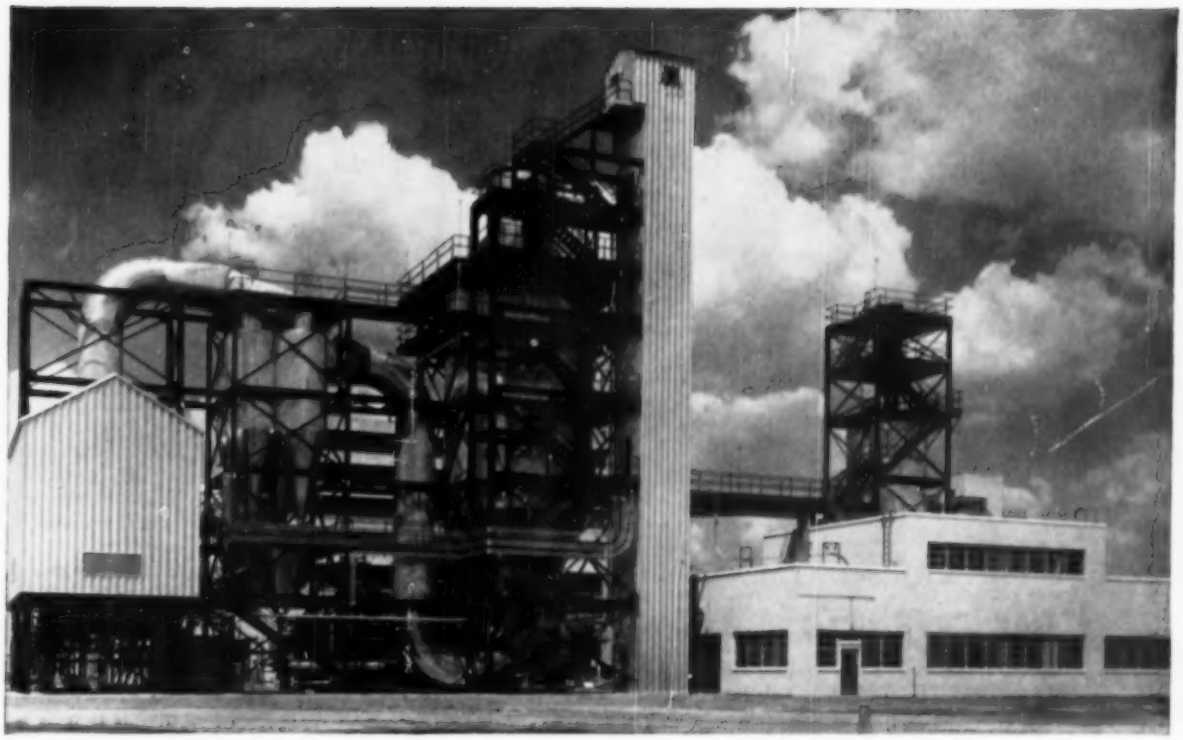
Engineering Nuclear Applications

The most significant fact developed by our technical people [in connection with the design and construction of the "Nautilus" and "Seawolf"] was that traditional engineering concepts were inadequate for the solution of the unusual problems posed by the nuclear power plant. When confronted with the application of scientific principles for which no technical experience existed, the engineering team often had to rely on extrapolation from the known and familiar—and even on intuition. Finding themselves in the unaccustomed role of direct interpreters for the scientist, they perforce had to translate his theory into actual practice. They had become, in effect, development engineers who spoke the language of the scientist but who knew how to translate that language into physical material.

Those of you who would enter the challenging new field of nuclear energy would be expected, I daresay, to fill this general job description. Your education has ensured that you will be practical, accurate, hard-driving, systematic individuals; but only experience will develop those additional abilities to bridge, say, the gap between quantum mechanics or La Place transforms and routine stress analysis. Equally important, as development engineers you may not be individual specialists. You must, paradoxically, have comprehensive specialties. For in the direct translation of broad scientific principles you will be called upon to correlate all engineering skills, and frequently to follow design concepts through to actual construction.

The installation of a nuclear plant and steam propulsion system in the "Nautilus" has had, and I dare say will continue to have, a major effect on many of the systems installed in submarine and surface and aircraft. All of you know that a "normal" nuclear power plant was adapted to the "Nautilus"—a tremendous engineering feat requiring compression into the narrow confines of the submarine hull of a reactor and complex equipment and systems around the reactor which

(*Continued on page 30*)



Corn Products' plant for spray-drying of Snow-Flake Instant Dried Starch, showing (left to right) filter, cyclones, spray-drier, elevator tower, and building for heating, preparation and packaging. All facilities are of stainless steel for sanitary protection.

Blaw-Knox completes second plant for Corn Products Refining Company

—new plant is first to use spray drying in the instant starch field

Applying the most modern food engineering techniques, Blaw-Knox designed and erected a new instant starch processing plant for Corn Products Refining Company at Corpus Christi, Texas. Spray drying is used to produce an improved product. The plant includes a starch precooking system, sanitary piping for transfer of precooked starch, and separate packaging facilities.

This plant represents but one of the process areas in which Blaw-Knox has long experience. Other fields include chemicals, resins and plastics, petroleum and petrochemicals, fertilizers, fats and oils, chlorine and alkali production, nuclear energy, synthetic fuels, and waste recovery.

We welcome the opportunity to explore your problems with you.

View from rear of plant shows giant spray drier in center, which rises to 88 feet above ground and is 24 feet in diameter with the cyclone separators at right.

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Chemical Plants Division

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*This illustration is an authentic engraving of a laboratory used by alchemists in Holland during the 1600's. For your copy (11"x15") of this reproduction, write on your company letterhead stating your name and title.

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Noted and quoted

(Continued from page 28)

on land might have been situated in acres of space. But in addition to the reactor problem, the taking of a steam system to great depths under water called for the most extraordinary engineering efforts—presenting whole new areas of engineering problems and requiring instant and original and correct solutions.

John Jay Hopkins at Commencement Exercises Webb Institute of Naval Architecture

Knowledge and Wisdom of Science

[An element] of novelty that science has brought to us . . . is a change in scale; it is not something wholly new . . . it is an inherent, necessary accompaniment of the great success of the sciences. It is not new that what has been learned in the recent past is more than was learned in all of man's earlier history. . . .

Positive knowledge, what is recorded in the technical books and learned journals, all of it that is new and true and not trivial, is of course not wisdom; it can on occasion almost appear incompatible with wisdom. I think that such positive knowledge doubles in less than a generation, perhaps in a decade. This means that most of what there is to know about the world of nature was not discovered when a man went to school; it means that universal knowledge, always, even in Leonardo's day, a dream, but not an irrelevant dream, has become a mockery; it means that the specialized sciences, genetics, for instance, or astrophysics, or mathematics, are like the fingers of a hand: they all arise from the common matrix of common sense, from man's daily experience, his history, his tradition, and his words. Each is now developing a life, an experience, and a language of its own, and between the tips of the fingers there is rare contact. For many centuries mathematics and physics grew in each other's company, in happy symbiosis. Today at their growing tips they hardly touch. Logic, psychology, philosophy were long studied in the same rooms, and often by the same man. Today they rarely speak to each other, and are more rarely understood or even heard. . . . These changes mean that ignorance is a universal, pervasive feature of our time. [This fact has] an essential relevance to the problems of education.

Condensed from an address "Science and Our Times" by J. Robert Oppenheimer, Director, Institute for Advanced Study, Princeton

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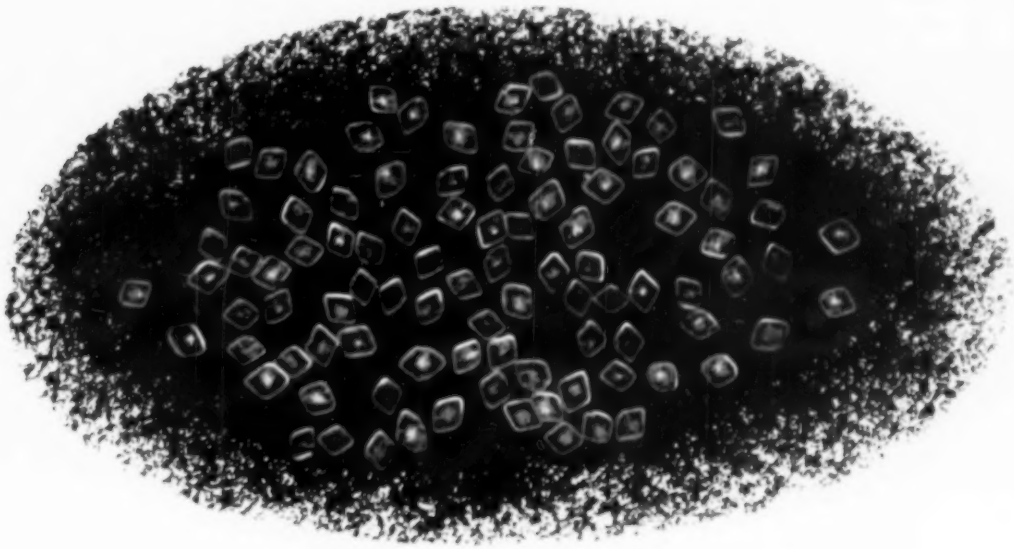

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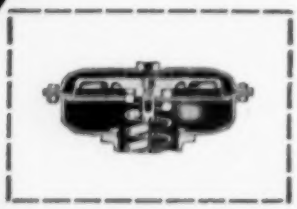
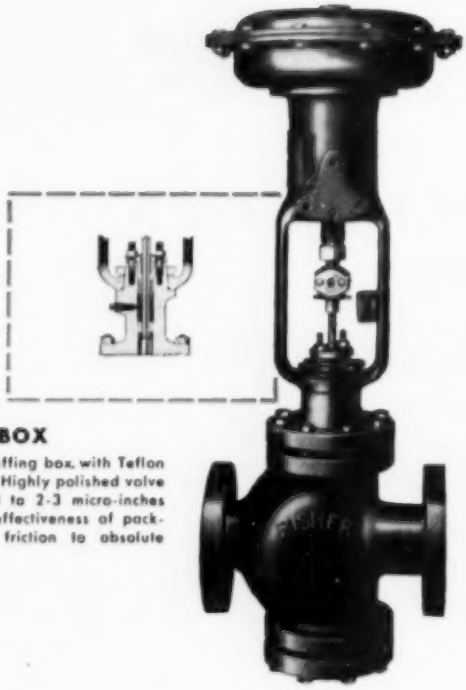


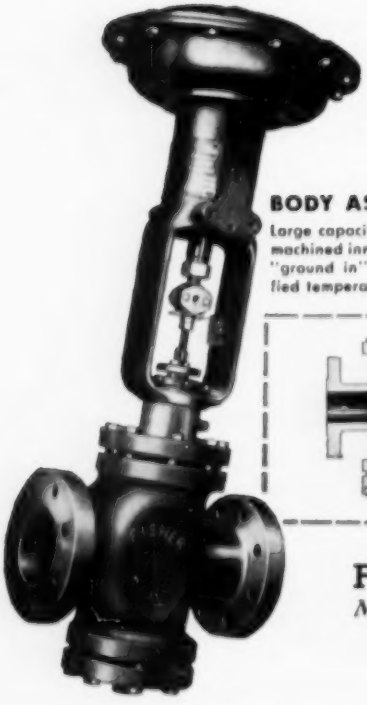
DIAPHRAGM ASSEMBLIES

Extra thick steel casings are zinc electro-plated, iridited and then given prime and final paint coats. Specially designed molded diaphragm with nylon insert gives practically constant effective area throughout valve stroke.



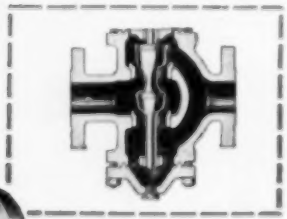
STUFFING BOX

Bolted gland stuffing box with Teflon V-Ring packing. Highly polished valve stem is finished to 2-3 micro-inches RMS to insure effectiveness of packing and keep friction to absolute minimum.



BODY ASSEMBLIES

Large capacity bodies with accurately machined inner valves are individually "ground in" under customer's specified temperature conditions.



Realizing their importance in the control system, Fisher has given careful attention to design and construction of diaphragm control valves. Any way you look at it — from the standpoint of durable construction or accuracy of performance—Fisher Diaphragm Control Valves are your best bet.

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Marshalltown, Iowa • *Woodstock, Ontario*

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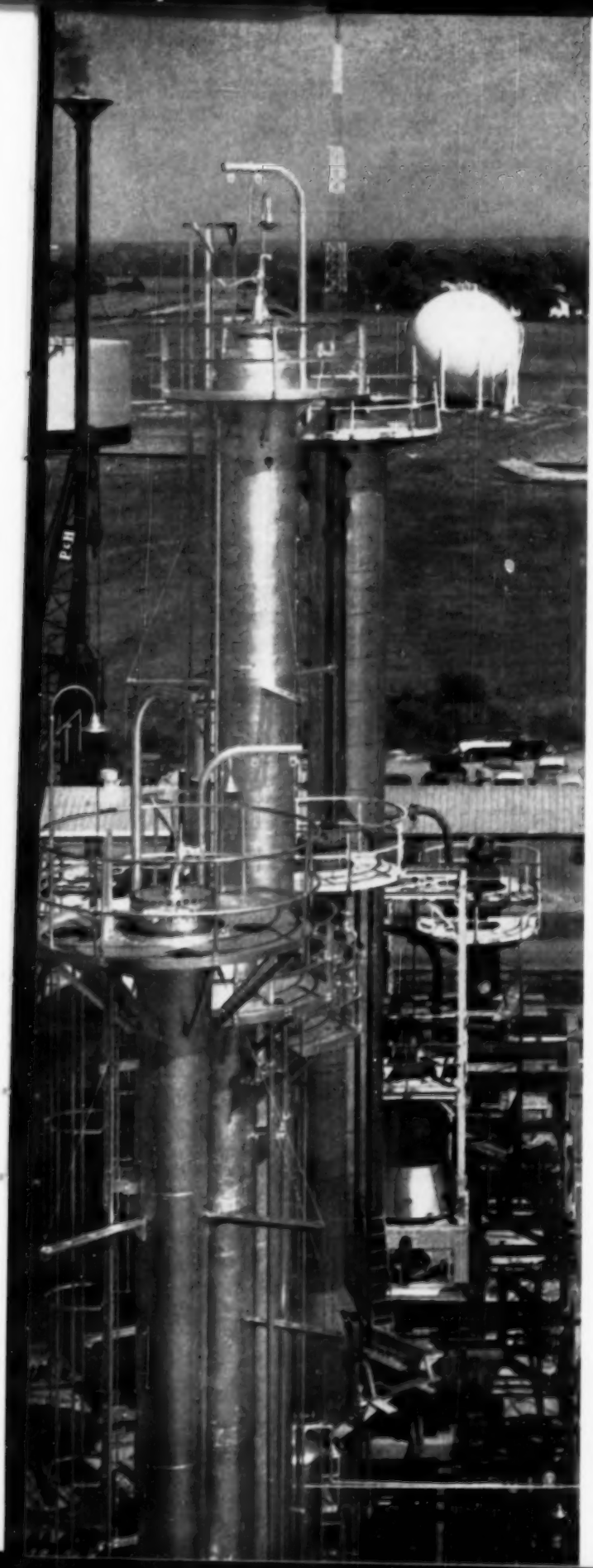

This SWECO-built refinery addition helped an Indiana plant pull from behind to a front position in the race to upgrade gasoline.

High Octane Package Handled with Care

Like many refineries, the Mt. Vernon plant of the Indiana Farm Bureau Association was caught with its rating down when the latest high octane race started. That was before SWECO wrapped up a $1,500,000 refinery package that included a 3,000 BPSD platformer, a 2,100 BPSD unifiner, and a new steam generating plant with an hourly capacity of 120,000 lb. of high-pressure steam.

Off and running

The platformer-unifiner team went on stream in November, 1956, and has been in continuous operation ever since. This combination unit, built under license from Universal Oil Products Company, makes Mt. Vernon a front runner in today's race to upgrade gasoline.

In planning the steam generating plant, SWECO engineers decided to save time by specifying the equipment and letting bids for fabrication. But outsiders couldn't meet the cost estimates or contract, so SWECO built the pressure vessels in its Los Angeles plant. They were delivered three days ahead of schedule.

Problems in stride

Heavy spring washouts and a tight budget were just some of the problems the SWECO engineering and construction crews took in stride. Designing and building moderate-size refinery installations is their specialty.

This is the kind of service, the extra service SWECO clients in the process industries expect. Large or small, at home or abroad, it's the only kind they get . . . in the *engineering and construction* of refineries (SWECO *is licensed to build plants for practically all major refining processes*), chemical plants and ore beneficiating mills . . . in the design and manufacture of *process equipment* such as heat exchangers, steam jet ejectors and distillation columns . . . in a full line of *vibrating screen separators*.

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Marginal notes

Nuclear Reactors and Radiations in Industry—Notes for an Intensive Course for Practising Engineers.

University of Michigan, College of Engineering Summer Session, 1956 Available from University Press, University of Michigan, Ann Arbor, Three Volumes, $10.50.

The three volumes comprising this series are a compilation of lecture notes and supplemental material originally intended for the use of students at the 1956 Summer Nuclear Engineering Session at the University of Michigan College of Engineering.

Emphasis throughout the series is on the practical industrial application of nuclear energy and on the engineering problems involved. However, sufficient basic nuclear physics is included so that the average chemical engineer trained in conventional engineering practice will have no trouble adapting his skills to this new field.

Written largely by highly qualified members of the University nuclear engineering staff, the three volumes cover almost the whole spectrum of industrial applications of nuclear energy. Volume 1 is intended to provide a solid understanding for the more practical considerations which follow. It comprises easy-to-follow discussions of basic physics, nuclear engineering measurement, interaction of radiation and matter, and elementary considerations in reactor design.

Volume 2, dealing with nuclear heat-power reactors and nuclear fuels cycles, will be of special interest to the chemical engineer. The scope of subjects covered includes: energy requirements and nuclear heat-power, nuclear fuels cycles for reactor types, nuclear thermodynamic principles, extraction of heat and energy from nuclear power reactors, heat-power cycles, and reactor systems and fuels reprocessing.

Volume 3 is entitled "Uses of Ionizing Radiation." The lecture notes here are divided into the following categories: sources of nuclear radiation, gamma radiation, radiation hazards and health physics, dosimetry, promotion of chemical reactions by gamma radiation, gamma irradiation of biological materials, design of gamma irradiation facilities, and example design of a radiation facility.

The simplicity and practical orientation of these volumes make it possible to recommend them to the working engineer who has neither the time nor the opportunity to attend formal nuclear engineering courses. —*W. H.*

Manual on Industrial Water—Third Printing, 1956.

(ASTM Special Technical Publication 148-B) Cloth Bound, 6 × 9 in., 502 pages, $6.00. American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa.

Sponsored by ASTM Committee D-19 on Industrial Water, this Manual contains an appendix in addition to a discussion of water, its uses, treatment, sampling, analysis, and difficulties caused by it.

The appendix lists ASTM standards relating to industrial water. It contains five methods of sampling, 41 standards, four methods of analysis, three standards for methods of reporting results, six standards for methods of test, a glossary of terms, a list of industrial water requirements, and a bibliography.

Included in the latest printing are seven new methods and one important revision. Two additional proposed methods are published as additional information. No changes have been made in the chapters of the Manual.

Protective Coatings for Metals. R. M. Burns and W. W. Bradley.

2 ed. Reinhold Publishing Corporation, New York (1955), 657 pages, $12.

Reviewed by Kenneth Tator, Kenneth Tator Associates, Coraopolis, Pennsylvania.

This revision of an earlier A.C.S. Monograph of the same title by Burns & Schuh has brought the subject matter of the earlier edition up to date, both in regard to the latest development in materials and application, and in respect to its complete listing of additional and source material in the technical literature.

In this work the authors have used their title "Protective Coatings for Metals" in its broadest and proper scope. Increasingly in large areas of corrosion prevention, the term *protective coatings* connotes only organic coatings and paints. Protective coatings, of course, are any resistant material, continuously adherent to and conforming to the surface of the metallic base to be protected. This proper and broad definition includes, but certainly is not confined to, barriers of organic nature. Thus, the authors devote some 300 pages to metallic coatings in their various forms, as well as some 200 pages to protective organic coatings.

As *protective* in this instance primarily means protection against corrosion, this volume starts with an excellent summary of corrosion principles. This discussion is followed by a complete and detailed working description of the various processes of surface preparation required for both metallic and organic coatings.

Descriptions of application, properties, and uses of all commonly used and many less common metallic surface coatings are fully presented. Application of these coatings by hot dip, cementation, cladding, sputtering, sublimation, electroplating, and spraying is fully covered. Within the organic coatings section all industrially used types of organic coatings are discussed in respect to their properties, potentialities, and limitations, and their industrial usage, and performances are thoroughly recorded.

In addition to these predominant types of surface coatings, attention is given also to conversion coatings, organic lining materials, and vitreous coatings. A chapter is devoted to corrosion inhibitors, not popularly considered as protective surface coatings. As there is considerable evidence to support the popular concept that corrosion inhibitors function by forming an inert, passive film over the surface, their inclusion in this work seems justified.

Evaluation and testing of all types of surface coatings are included.

This volume can be recommended to plant engineers, design engineers, and corrosion engineers as an integral part of their working bookshelf.

Corrosion: A Compilation, Mars G. Fontana.

The Press of Hollenback, Columbus, Ohio, 240 pages, $5.95 (1957).

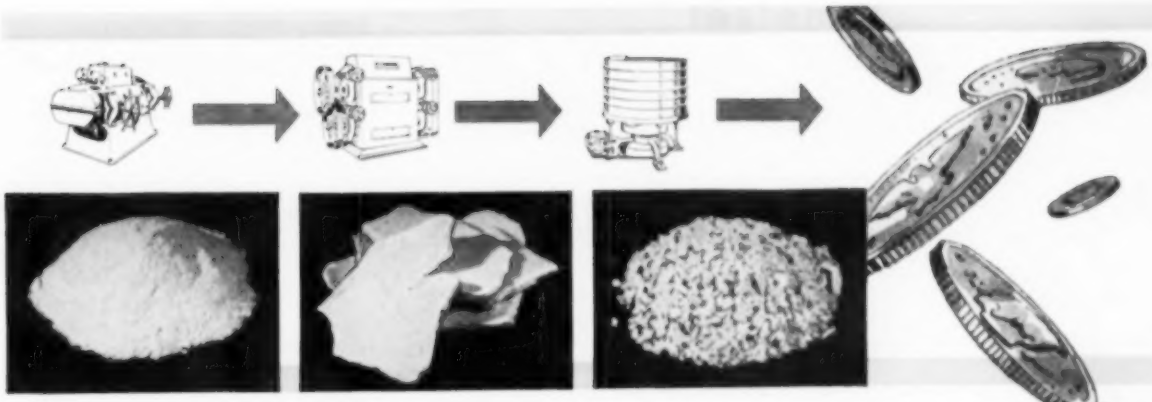
An exhaustive survey of the corrosion problem with special emphasis on the chemical process industry. Data are given for almost all metals and alloys used in anti-corrosion service as well as for many non-metallics. Especially valuable are iso-corrosion charts which show corrosion as a function of concentration and temperature for materials of construction in a variety of different acids.

Case histories are included which give details of actual corrosion experience in plant operation, and methods are explained for making laboratory and plant corrosion tests.

Separate chapters cover: nature and extent, eight forms of corrosion, eight methods for combating corrosion, corrosion testing and evaluation, materials, environment, and high temperature oxidation.

The compilation can be recommended as a reference book for the plant engineer and as a general textbook for use in courses on corrosion.

—*W. H.*



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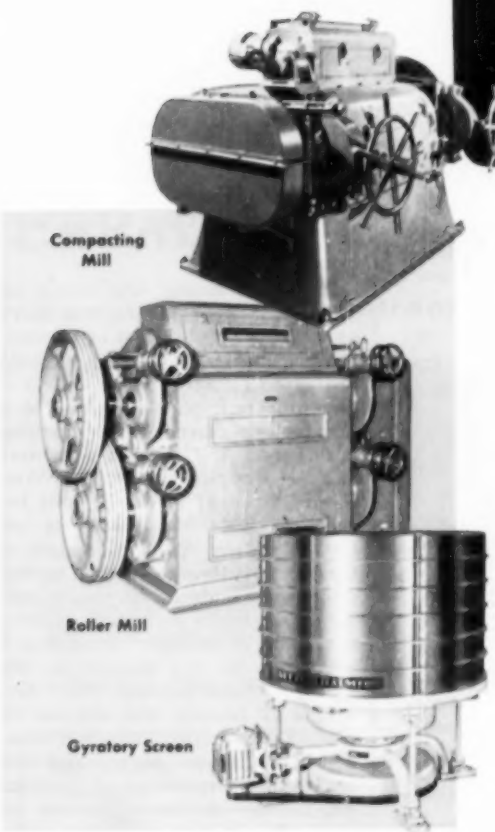

You start with a pile of practically worthless material and wind up with a profit! Magic? Well, hardly — unless you want to call the mechanical efficiency of the Allis-Chalmers Process System magic.

How It Works

In a recent installation the conversion starts with an unusable, unacceptable minus 30 mesh chemical salt . . . fines created in the original process. An Allis-Chalmers compacting mill densifies these fines into flakes or slabs. Flakes are granulated in an Allis-Chalmers roller mill. Final separation is made in an Allis-Chalmers stainless steel gyratory screen. Result — 70 to 80% recovery of salable product. What's more — the resulting granules equal or surpass the natural product in every respect.

The entire system is mechanical; therefore, it's more economical than controlled crystal growth.

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Get the complete story from your A-C representative or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wisconsin. Ask for Bulletin 25C6177J.

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A JOURNAL OF USEFUL INFORMATION FOR THE SOLUTION OF CORROSION PROBLEMS

Chemical Resistance of Tantalum to Fluorine, Chlorine, Bromine and Iodine

Fluorine attacks tantalum at room temperature. It is not known, however, what the rate of attack is at low concentrations of fluorine in gas mixtures.

Chlorine begins to attack tantalum at above 200°C, the rate increasing as the temperature becomes higher. Wet or dry, chlorine does not affect tantalum at temperatures ordinarily encountered in chemical processes. Thus, while the metal cannot be used for high temperature chlorinations, such as the production of titanium tetrachloride by the reaction of chlorine on a mixture of TiO_2 and carbon, it is widely used for chlorinations in aqueous and organic solutions at temperatures below 200°C. Tantalum is also inert to the hydrolysis products of chlorine, at all concentrations. It finds use in the form of meter components, thermowells, sparger tubes, heaters and heat exchangers handling free chlorine or chlorine-containing solutions in a great variety of chemical processes ranging from the introduction of chlorine into municipal waters to the heating and cooling of chlorinated brine in electrolytic cell plants producing chlorine and caustic.

Bromine begins to attack tantalum above 300°C. Tantalum is inert to bromine, wet or dry, at temperatures ordinarily encountered in chemical processes. In the bromine industry it is used to handle both chlorine and bromine. (See "Corrosionomics," July, 1956). Units condensing hot (190°-212°F) bromine containing water and chlorine have been in continuous use for 20 years without corrosion of the tantalum. Tantalum is inert to the hydrolysis products of bromine, at all concentrations, and is widely used for brominations in aqueous and organic solutions at temperatures below 300°C.

Iodine attacks tantalum above 1000°C, but the metal is inert at lower temperatures. In high temperature application, tantalum is used as a shield in the deBoer and van Arkle process for the preparation of pure metals, such as titanium and zirconium by the decomposition of metal iodides on a hot filament into the metal and free iodine.

The interhalogen compounds, with the exception of those containing fluorine, likewise do not attack tantalum at normal temperatures.

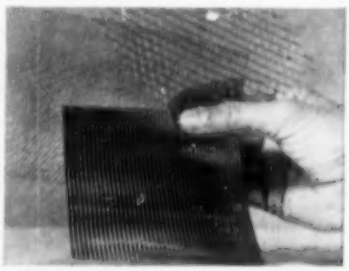
EXPANDED TANTALUM SHEET

It is now possible to fabricate expanded tantalum sheet in thicknesses from 0.003 to 0.075 inch and in widths up to 54 inches.

Sheet widths larger than 54 inches can be produced by welding smaller widths together.

Expanded tantalum sheet should prove useful as screens for chemical equipment exposed to acidic and other media which do not attack tantalum; anode baskets in electroplating baths; support screens for retaining packing in towers; and supports for glass and synthetic fiber cloths used in filters and centrifugers.

Platinum can be deposited as a thin coating upon expanded tantalum and the composite should be useful as catalyst screens and as anodes for electrolytic cells. In these applications tantalum acts as an inert support material and reduces the amount of platinum required.



Tantalum can be produced in a variety of meshes.

Free Tantalum Test Kit

A corrosion test kit, available without charge to research technicians, contains both tantalum sheet and wire. Request it on your letterhead.

The above condensation is typical of articles which appear in CORROSIONOMICS, a Fansteel publication. Mail us your name for inclusion on our mailing list.

For further data on the above, write

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About our authors

Lincoln R. Thiesmeyer, who leads off *CEP's* special section on what's happening in pulp and paper technology, is an outspoken advocate of progressive thinking about the future of that industry. President of Canada's Pulp and Paper Institute, Thies was trained as a geologist, taught and did research in that field for 14 years. Moving along to administration of scientific programs during the war, he became senior administrator at Brookhaven National Laboratory before going to the Canadian Institute. He feels that such a background has given him no preconceived prejudices, enables him to "challenge the thinking of management, operators, and technical people in the industry and to needle them into action in new and revolutionary directions."

George Olmsted, Jr., author of the article interpreting the effect business conditions in the paper and pulp industry may have on its technologic development, is an outstanding spokesman for management of that industry. As president of S. D. Warren Co.—a major paper manufacturer—since 1944, George is continually sought as a speaker by various organizations to bring them up-to-date on goings on within the industry. A past president of the American Paper & Pulp Assn., he is also a director of several corporations.

Roy P. Whitney, who writes on training of the men who will carry on with the establishment of an ever-increasing scientific base for the pulp and paper industry's operations, is a firm believer in the importance of a sound chemical engineering training in this task. As Dean of the Institute of Paper Chemistry in Appleton, Wisconsin, his most recent concern beyond the basic one of turning out PhD's has been directing research in recovery of chemicals from neutral sulfite spent liquors, with results leading to industrially interesting possibilities. Roy is currently organizing a symposium on this subject for the Chicago Annual Meeting (Dec. '57).

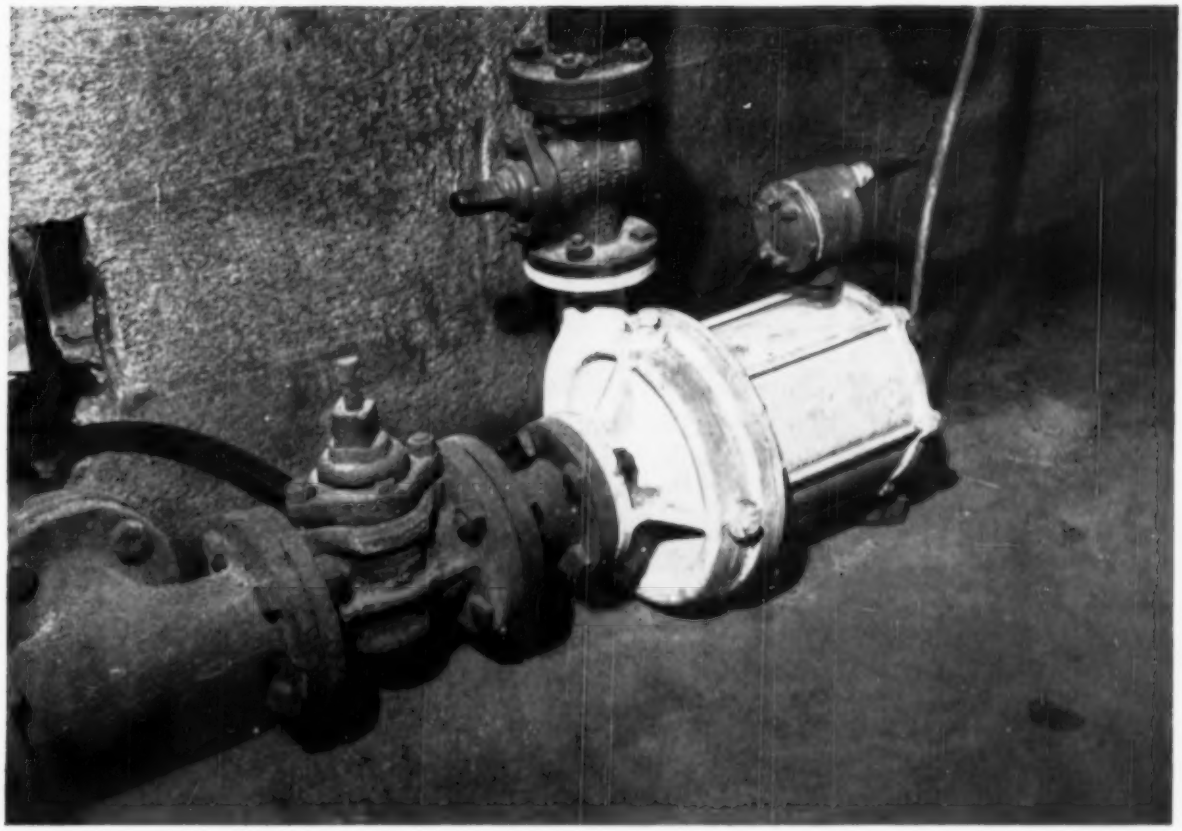
Lyle C. Jenness, who analyzes the chemical engineering manpower situation in the pulp and paper industry, is head of the Department of Chemical Engineering at the University of

(*Continued on page* 40)

Thiesmeyer

Olmsted

Whitney



Chempump solves leakage problem

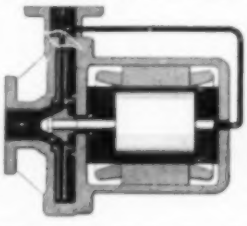
handling carbon tetrachloride at chlorinated products plant

Carbon tetrachloride is tough to handle. It's "slippery", and has a way of oozing through even the best seals and packing. At this major chemical company's chlorinated products plant, conventional centrifugals were used to pump carbon tetrachloride from storage tanks to drums and tank cars. Stuffing box leakage was a persistent problem. Maintenance and downtime costs ran high.

Like many other chemical processors, this company uses *Chempump* to tame hard-to-handle fluids. Since replacement of the conventional centrifugals with two *Chempumps*, leakage has ceased to be a problem. The only maintenance required on the pumps, now well into their second year of service, has been a precautionary change of bearings. External lubrication is eliminated—bearings are constantly lubricated by the pumped fluid itself.

There's a good chance that *Chempump's* many unique advantages can be profitably applied in your own processing operations. For details, write to Chempump Corporation, 1300 East Mermaid Lane, Philadelphia 18, Pa. Engineering representatives in over 30 principal cities in the United States and Canada.

No seals, no stuffing box, no leakage



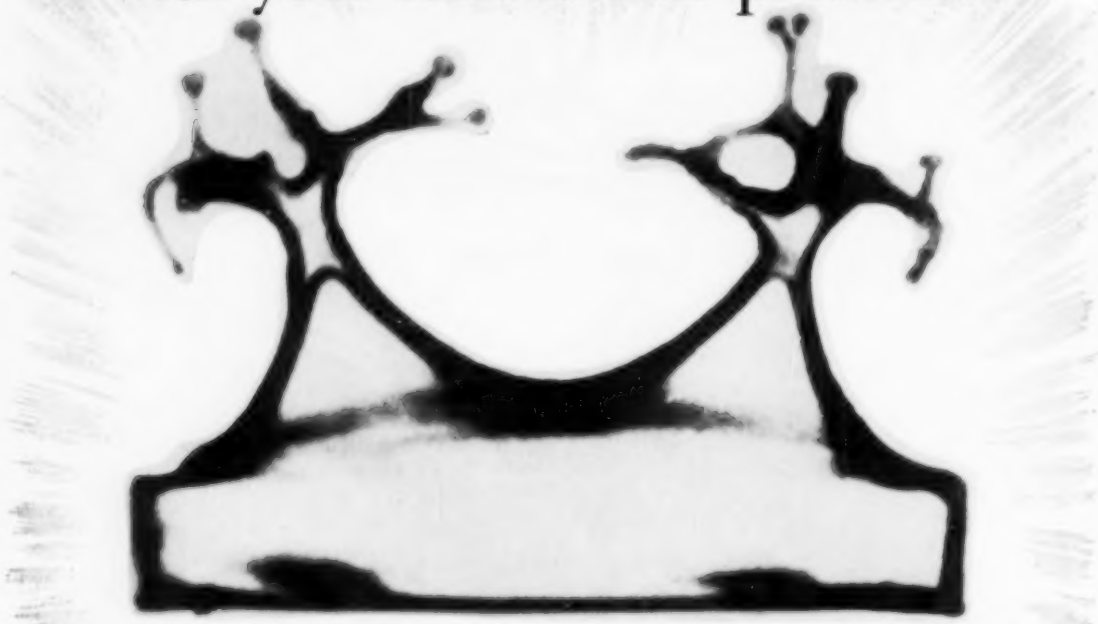
Chempump combines pump and motor in a single leakproof unit. No shaft sealing device required.

U.L. approved. Available in a wide choice of materials and head-capacity ranges for handling fluids at temperatures to 1000 F. and pressures to 5000 psi.

Chempump

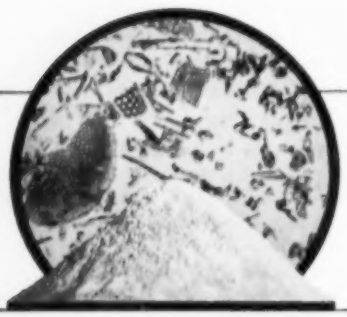
First in the field...process proved

What's this "CROWN" got to do with your formulation problems?



This is a particle of Celite diatomaceous earth. The genus is *Dicladia,* species is *Capreolus.* Loosely translated it means "two-sided branch." This particle is just one of hundreds of different intricate particles that together make Celite such an efficient mineral filler. When placed under a microscope *Dicladia Capreolus* becomes a rustic "crown."

It's a particle of CELITE with a cubic foot



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About our authors

(Continued from page 36)

Maine, won the University's Pulp and Paper Foundation Honor Award in 1954. An outstanding exponent of the application of chemical engineering to pulp and paper industry operations, Jenness' professional career has been in training men for the field, and directing research.

E. Clinton Bowen, president of The Bowen Corp., Cambridge, Mass., deserves special mention in connection with *CEP's* current articles on pulp and paper technology. Clint organized and acted as chairman of the symposium on this subject (at the recent Boston Annual Meeting) from which our articles were derived.

O. A. Ohmann, author of *The Innovator* in the front section of this issue, is director of Organization Planning and Management Development with Standard Oil of Ohio, a position which involves him in problems of manpower effectiveness in various managerial and professional assignments. Ohmann tells *CEP* that it is not uncommon for him "to find professional or staff men whose creative output is frustrated either because of the limitations within the form of organization or the restricting attitudes of the organizational 'climate'." Ohmann's indicated solution: delegate not only *authority* in the usual way, but also a favorable *climate* to keep up enthusiasm and the flow of new ideas.

Arthur C. Dreshfield, Jr. (*Mechanism of Hot-Surface Drying of Fibrous Sheets*) is in research and development with the Scott Paper Company. A product of Whitney's Appleton Institute, Dreshfield's work in the field of hot surface drying demonstrates valuable new concepts in the field.

Chemical engineer **William E. Katz** (*Status of Electric Membrane Demineralization*) is treasurer and sales manager of Ionics, Inc., developers of the electric membrane process. Katz works in an area which brings him in close contact with his public—providing potable water. Several years ago he demonstrated Ionics' electric membrane demineralizer to the citizens of Grafton, N. D., with gratifying response. Says Katz, "I will never forget the interest and courtesy of these people, who had lived for many years with an

Jenness

Ohmann

Munro

abundant supply of completely unpalatable water. They assembled in the City Hall to see the demonstration, and afterwards came up carrying pitchers, mason jars, and cups to get a sample of their water rendered potable by demineralization. Afterwards, I sat with some of the people in a restaurant opposite the City Hall with jugs of treated and untreated water of different salinities while the obliging proprietor made a series of coffee tests and the merits of each preparation were hotly debated. It was here that I first glimpsed the meaning of good potable water to a town population, a knowledge that has given me personal encouragement to continue with the technical and business problems involved in creating a new type of water treatment equipment."

W. H. C. Simmonds, author with **J. A. A. Greathead** of the article *Mixing Patterns in Helical-Flight Dry Solids Mixers,* is now in the development department of Canadian Industries, Ltd., with a background as a teacher (in England) of chemical engineering. He writes: "In 1947 I had to start a new post-graduate course. It was obvious that the subjects of size reduction and mixing of solids were in an unsatisfactory condition for teaching. It seemed also to be clear that the unit operations concept was a method of analysis, and that progress could only come from a study of the physical mechanisms underlying these various operations. This led to the recognition of size reduction as a nucleation process similar in mechanism to ebullition, crystallization, etc. (see *CEP*, **52**, 139, 1956). Further thought indicated that mixing of dry solids shows several analogies with size reduction [as I point out in the current article]."

Paul Haas, author of the article on liquid cyclones, chose to stay with Oak Ridge National Laboratory as an equipment development engineer, following a year's specialized training at ORSORT, the Oak Ridge school.

I. H. Munro is a top executive of Solvay division of Allied Chem. & Dye. Joining Solvay immediately after finishing graduate training at M.I.T., Munro has held various posts. Munro's analysis of the future of raw materials for the inorganic industry is based on a recent A.I.Ch.E. Greenbrier talk.

Roger Williams, Jr. (plastics futures) is president of his own economic analysis consulting firm, recently moved his headquarters to calm, contemplative, Princeton, N. J. A former DuPont cost engineer and plastics developer, Roger served a term on the editorial staff of another magazine in the chemical field.

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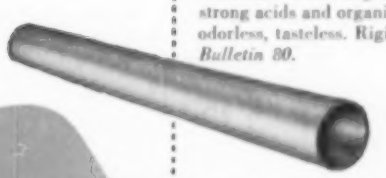

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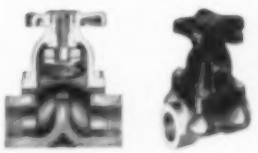

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HEAT EXCHANGERS—STEEL AND ALLOY PLATE FABRICATION
CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

Now that all of the annual reports of the chemical producers are out and available for study, the results point up the reasons why many executives see cause for some soul searching.

The chemical industry has been glorified in investment circles for many years as a "growth" industry, based on the idea that research and the constant stream of new products should mean a steady upward growth in sales and earnings.

The annual reports of virtually all the leaders in the industry showed gains in sales volume, many hitting new high records. But only a few big chemical firms showed any substantial gains in earnings. Most showed declines from 1955 and others showed only nominal increases in net profits per share.

The main reason is the squeeze on profits caused by higher wages and the rise in other costs. So far this year chemical executives are unwilling to forecast what 1957 will bring. They are again fairly confident of a further gain in sales, but the picture on profits is less clear and many feel that the full picture will not be revealed until the second quarter of the year is well along. There is no indication of a halt in the rising spiral in wages and other costs. There is also the factor of slowdowns in such major consuming industries as automobiles and home building.

Chemicals Down

Six of the largest chemical firms listed on the New York Stock Exchange showed declines in earnings per share last year as compared with 1955. One, Union Carbide, showed earnings unchanged at $4.86 a share. Five companies, all but one on the smaller side, showed gains. American Cyanamid was able to show a moderate increase in net to $4.21 a share from $4.07 a share.

The nation's biggest chemical firm, the Du Pont Co., reported a drop in net to $8.20 a share from $9.26 a share earned in 1955. Its earnings from chemical operations, not including its dividends from General Motors, declined to $5.65 a share from $6.51 a share in 1955.

In the report, President Crawford Greenewalt pointed out that in the three years since 1953 wages had gone up 18 per cent, whereas Du Pont's index of its prices had declined 6 per cent. Du Pont, with a heavier interest in textiles than any other chemical firm, suffered from lower prices for its newer synthetic fibers, notably nylon, and also from depressed conditions in the rayon industry. Total sales were down 1 per cent.

Allied Chemical & Dye was another big firm to show a drop in profits per share to $4.88 a share from $5.44 a share in 1955, in spite of a 6 per cent increase in sales to a new high record. Allied, a major producer of nitrogen fertilizers and ammonia, suffered from lower prices and depressed conditions in the fertilizer industry, as well as high costs.

Olin Mathieson, also heavy in the fertilizer business, showed a decline in net per share to $3.38 from $3.51 a share in 1955. Dow, always rated high as a "growth company," showed a drop in net to $1 a share for the six months ended November 30 from $1.22 a share in the 1955 half year. Monsanto declined to $1.80 a share from $1.98 a share in 1955. On the other hand, Air Reduction, National Cylinder Gas, American Potash & Chemical, and Diamond Alkali all showed nice gains.

Wall Street analysts, however, are not yet ready to be discouraged about one of their favorite industries for investment. At a recent symposium before the N. Y. Society of Security Analysts, some leading financial experts on this industry forecast a continued average growth in the rate of sales of 7 per cent. They also forecast materially larger earnings for a number of the leading firms in 1960, "guestimating," for example, that Du Pont might be earning around $8 to $11 a share at that time without taking into account its income from General Motors. Guesses were that Union Carbide might be able to get its net up to nearly $8 a share by 1960.

Pharmaceuticals Up

In contrast with the chemical industry, drug companies uniformly showed comfortable gains in earnings per share. Abbott Laboratories reported $2.80 a share against $2.48 in 1955 and $2.21 in 1954. Bristol Myers, mostly in proprietary drugs, gained to $3.55 a share from $2.98 a share in 1955. Sales of a new antibiotic and of its "Bufferin" helped.

Merck was able to show a gain to $1.92 a share from $1.55 a share in spite of sharp cuts in the price of vitamins, an important factor in sales. Tightened management was one reason for improvement. Pfizer gained to $3.36 a share from $2.94 a year in the previous year.

The most phenomenal gains, however, were marked up by American Home Products and Schering Corp. American jumped to $8.14 a share from $5.34 a share. American is a large highly diversified company making both trademarked drugs and ethicals, which are sold through its Wyeth division. A new tranquilizer drug brought out by Wyeth was a factor last year.

Schering has probably had the best growth record lately of any drug company, due chiefly to its pioneering in the newest cortisone-type drugs for arthritis. Net last year was $6.04 a share against $4.71 a share in 1955 and a modest 89 cents a share in 1954.

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opinion and comment

IN TIME OF PEACE

These are good times, almost unbelievably good times. Prosperity, peace, immense growth in science and technology, and almost boundless consumer demand are keeping our plants operating at a high level and justifying further expansion.

Emerging victorious from the last global conflict, our nation soared to new heights of power and prosperity; it will doubtless go even further, sparked by the efforts of dedicated individuals working in front of as well as behind the scenes in commercial, political, and military areas. We have reached a point where we are enjoying the highest standard of living our nation—perhaps any nation—has ever known, a standard for other peoples of the world to admire and strive in turn to achieve for themselves.

With military actions in the world shrunken to such a level as to free most of our citizens from the personal problem of compulsory service, we can devote, as individuals, more and more time to thinking of our personal satisfactions, our frustrations, the attitudes of our employers, the public, etc. Those who gave two, three, five, or even six years of their lives in World War II may very well feel that they deserve prolonged prosperity and some time for preoccupation with their personal problems.

But while we as a nation are enjoying this power, this level of productivity of consumer goods (and the world prestige that goes with them) we are doing so at the risk of continued and increased independence on imports by sea lanes of vital raw materials such as metals and even wood pulp. At the same time, there is growing in certain sections of the world an enmity directed toward our prosperity, a prosperity based on our ability to command, through our energy and wealth, so much of the world's raw materials. Within just the last five or six months, *CEP* has been the instrument for sounds of warning (from authoritative sources) that our nation cannot consider itself indefinitely secure in obtaining these vital raw materials in the quantities our standard of living demands. Furnas, while Assistant Secretary of Defense for Research & Development, sounded this note some months ago; it was echoed only last month by economic geologist Schwartz of the University of Minnesota. Now, in this issue, heavy chemical industry man Munro reaches, through his own experience, some of the same conclusions.

At the same time, it is heartening to be able to pass along news (such as is reported in this issue) of decisions to go ahead with large scale projects which will so increase our supply of nickel. Readers who follow "What's happening in industry" will recall other project announcements, all of which, through our screening operations, represent applications of chemical processing.

Credit is certainly due the industrial organizations which are forging ahead in these directions, credit which in these days of scientific and industrial "wonders" may not be fully appreciated unless a national emergency of sufficient magnitude to demonstrate fully the true value of these accomplishments should arise.

Individuals involved—and this, by reason of *CEP*'s distribution pattern, is aimed at chemical engineers—might consider that they are taking part in the kind of venture which is now simply a "job," but in times of national emergency would have a decidedly patriotic label. They may take pride in their contributions to the security of the most precious possession any people has ever achieved—our freedom.

—JBM

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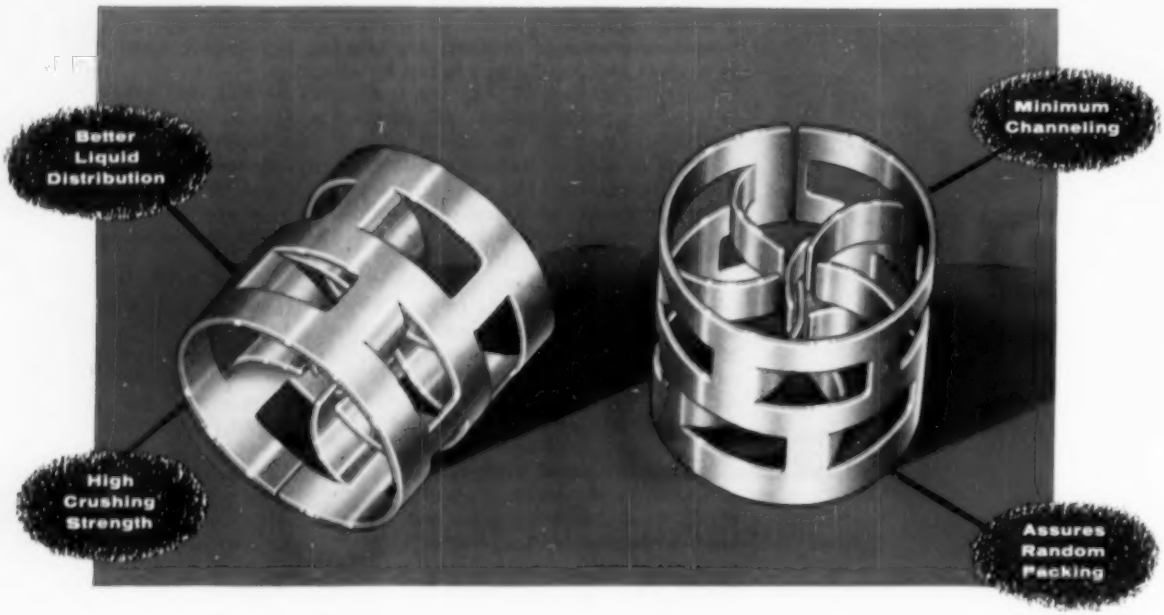

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REVOLUTIONARY TRENDS

in pulp and paper technology

L. R. Thiesmeyer | President, Pulp and Paper Research Institute of Canada, Montreal, Canada

The chemical engineer may soon become one of the most important people in the still expanding and potentially even more enormous paper and pulp industry. Such a thesis is based on my conviction that this industry is on the verge of at least three *revolutionary* changes which may well occur within the very short span of the next ten years. All three will require the talents of the chemical engineer as a key member of the scientific team to bring these things to pass. That only ten years may be required for the completion of these changes is based on the momentum of science and technology these days, on the fact that management of the industry is already much more research-minded, and on the fact that the industry is becoming much more competitive.

As interpreted from present-day trends in the pulp and paper mills, and from knowledge already available in the research laboratories, these three major, revolutionary changes will be:

1) the merging of mechanical pulping (creation of pulp by simply grinding up wood) with chemical pulping (manufacture of pulp by chemical separation of the fibrous from the nonfibrous constituents of the wood or other cellulosic starting material);

2) conversion of chemical pulping from batch to continuous operations at very high speeds; and

3) addition of (liquid) processing as a major activity of the industry for the production of by-product chemicals.

The Merging of Mechanical and Chemical Pulping

CHEMI-GROUNDWOOD

During the past few years, it has been found that when wood is given a steam treatment to raise its temperature and then a mild impregnation with a chemical solution to soften and plasticize the constituents which hold the fibers together, without actually accomplishing what could properly be called chemical pulping, the wood can then be pulled apart into fiber bundles and constituent fibers very readily and quickly by mechanical processes. This material is then reduced to papermaking pulp by further mechanical brushing out of the fiber bundles. One variant of this is the so-called "chemi-groundwood" process, developed at Syracuse University and now in mill use at Great Northern Paper Co. at Millinocket, Maine. This unit employs very large batch digesters into which whole logs are fed. After steam treatment and chemical impregnation under pressure the wood is pulped mechanically by grinding.

SEMICHEMICAL

Another variant is the "semichemical process," in use at a growing number of mills, in which wood chips are subjected to a relatively brief chemical treatment, generally at low concentrations of sodium-base alkali or acid, and are then pulled apart into pulp by machines known as "refiners" which shear the wood parallel to the long dimensions of the fibers and

brush out the fiber bundles and fibers to produce an acceptable pulp for papermaking.

HIGH-YIELD CHEMICAL PULP

A third variant of this partly chemical and partly mechanical processing can be seen at the Gould Paper Co. in Lyons Falls, N. Y. There, a control console regulates the feeding of wood chips and cold caustic solution into a Bauer rapid-cycle digester which operates on the basis of the repeated treatment of relatively small batches for short intervals of time, and then the feeding of the soaked chips into a refining operation which produces a pulp that can not only be substituted for some of the groundwood in newsprint and book papers but also can be a major pulp in other types of papermaking by itself.

TRENDS

The trends in these developments are: to shorten the total time of processing, to carry out the sequence of operations continuously and under increasingly automatic controls, and to integrate the chemical and the mechanical aspects of the process so completely that the terms "semichemical," "chemi-groundwood" and "high-yield chemical pulp" (which requires mechanical separation to reduce it to pulp) are losing their earlier, separate connotations. It becomes increasingly difficult to distinguish where the interests and responsibilities of the chemical engineer or chemist leave off and those of the mechanical engineer begin.

Extension of these trends more deeply into either the whole realm of strictly chemical pulping—or, if you prefer, into the realm of strictly mechanical fiber separation—should lead to a telescoping of the steps now carried out sequentially into even faster processes which might be called either "chemico-mechanical," or "mechanico-chemical," according to the predominance of either chemical or mechanical operations respectively. This will become a field for the chemical engineer (because of his training in fluid mechanics as applied to chemical processes) more than it will be one for the mechanical engineer who still manages to get by without much knowledge of chemistry. Another way to state this is, to remain dominant in this field, the mechanical people who have had so much to do with the development of the industry to its present status will have to pay more attention to chemistry than they have in the past.

Continuous Chemical Pulping at High Speeds

Chemical pulping is today almost everywhere a batch operation—slow, clumsy, and not too efficient. The equipment has grown to such size that the capital plant needed to get into the business on a competitive basis represents investment of scores of millions of dollars. And, as a corollary, the forest reserve needed to feed such a huge plant for its useful life must be very extensive.

Pressures for ever greater production to meet the seemingly insatiable demand for pulp and paper products (which, it is predicted, will more than double by 1980) have already caused a shortening of the total time cycles of the batch operations from many hours to only a few hours. This has been accomplished by juggling the variables of temperature and pressure, liquor composition, packing of wood chips into the cooking vessels or digesters, and pretreatments of the wood to achieve faster and more complete penetration with the cooking solutions. It has been done through a good deal of purely empirical experimentation, guided and abetted by much laboratory research. But always attempts toward speeding up of existing types of operations have been limited by the design of the equipment—by the sizes and capacities of lines, valves, and steam plants, by the difficulties of getting uniformity and speed of liquor penetration or circulation or heat transfer in vats which hold upwards of 15 tons of raw material per batch, and by the sheer problem of handling so much material at any one instant.

CONTINUOUS DIGESTERS

But there is now a well-established and accelerating trend toward the redesign of basic parts of the equipment to better accomplish higher throughput. One example of this is seen in the continuous digester. Dozens have been installed in various parts of the world since the end of World War II—as the only units in new mills, and as replacements and supplements in existing mills. They seem to have all the advantages which chemical engineers are accustomed to associate with continuous versus batch operations—reduced capital and operating costs, greater uniformity of performance and product, ease of automatic control, shorter cycles, and so on. For these reasons they could sweep the industry to replace existing batch units. That they do not is simply because such huge capital investments as are represented by the conventional batch-digester equipped plants cannot be written off suddenly without sharp dislocations in the industry's (or at least the individual company's) economy.

Used at first primarily for rather coarse grades of pulp, these continuous units and the processes related to them are now being adapted and adjusted to produce high-quality products. With wood materials as the feed, most of these continuous units operate on cycles from two or three hours down to less than an hour. And with a feed of sugar cane waste or bagasse, and with a new chemical process, a mill in Peru is reported to have produced various grades of pulp in cycles ranging from ten minutes down to two minutes—which is really high speed compared with the long cycles of yesteryear!

NONCONVENTIONAL HEATING; PORTABLE PLANTS

The spreading of such continuous chemical-pulping operations would in itself constitute a revolution in the industry—one in which the growing importance of the chemical engineer must be obvious. But even more revolutionary changes are in store when knowledge presently available in the research laboratories is translated into commercial practice with their help. We know, for example, that when wafers of wood only 0.02 to 0.05 in. thick are prepared in a waferizing machine (now commercially available) and are penetrated thoroughly with cooking liquors (an operation which takes only a few seconds, as contrasted with the difficult and time-consuming penetration of chips up to 0.5 in. thick and full of interstitial air that impedes penetration by the cooking liquor), these wood wafers can be reduced to high quality pulp in 30 seconds or less! This could not possibly be done in conventional batch equipment. It depends on a very sudden and very uniform rise of the temperature to the cooking or reaction level to bring about rapid treatment and to avoid inequalities of treatment or even localized damage through uneven cooking conditions. That calls for some completely nonconventional method of heating to temperatures of 150°-250° C., such as by radio frequency waves, and for exceedingly swift mechanical handling to move the material through each phase in the treatment from raw wood to pulp. In short, this means very high speed continuous pulping. And it will be accomplished in plants which can produce many tons per day even though they are small enough to be portable or semiportable so that they can be placed right in the woods, close to the

source of the wood supply, eliminating the costly handling and rehandling of the wood to the mill. What an aid the small, packaged atomic power plant will be in this case!

Such high-speed operations will make the chemical pulp mill of the future resemble more closely in its design features the modern petroleum refinery or petrochemical plant, with its complexes of pipes and valves and its high degree of automatic control. How soon the pulp and paper industry will have such plants will depend in part on how quickly chemical engineers seize the opportunity of helping to design and build them.

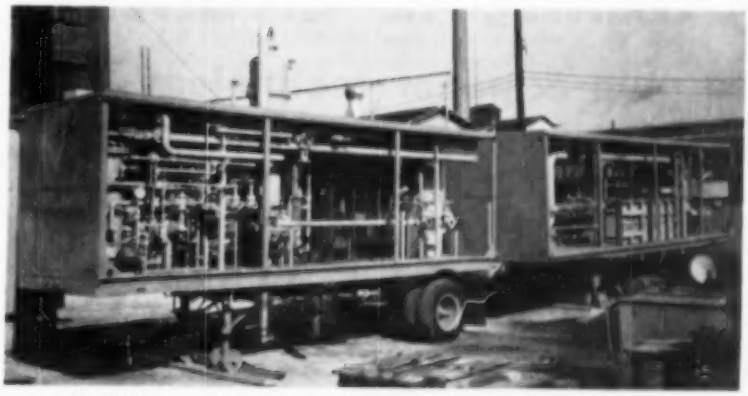
Production of By-Product Chemicals

It has been forecast that, through processing of its spent liquors into chemical by-products, the pulp and paper industry would become a chemicals industry.

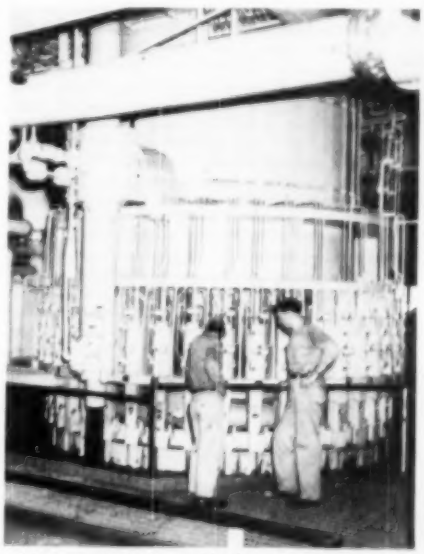
Only five years ago, a Monsanto executive told a technical society meeting that in his opinion no greater opportunity faced the chemical engineers and chemists of this continent than in careers having to do with waste recovery, both liquid and solid, in the vast pulp and paper industry. Perhaps such considerations have led to some of the marriages of chemical companies and pulp companies which has been seen in the past ten years. They certainly do provide the basis on which a large pulp producer like Crown Zellerbach, for example, has launched a silvichemicals division, to be of stature equal to its other divisions. So, here and there all through the North American pulp and paper industry, strong efforts are now being made to extract by-products and develop markets for them. Yet, millions of tons of what many regard as "liquid gold" are still flowing away in streams, or being poured on gravel roads as a stabilizer, or burned. This is all too strongly reminiscent of the thousands of awesome flares which once illuminated our oil and gas fields when billions of cubic feet of precious hydrocarbons were burned to avoid a storage hazard.

What is needed is for the know-how in market research and in processing, the quick thinking and venturesomeness of the chemical industry to be more widely applied to this opportunity in pulp and paper. It is already happening at an accelerating pace. So the day of the by-product recoverer's vision is not far distant.

For many years, pulp mill effluents were studied chiefly by *organic* chemists. They published literally thousands of papers on the possibilities of extracting various exotic chemicals, generally in low yields, from only small proportions of the total effluents, and for microscopic or non-

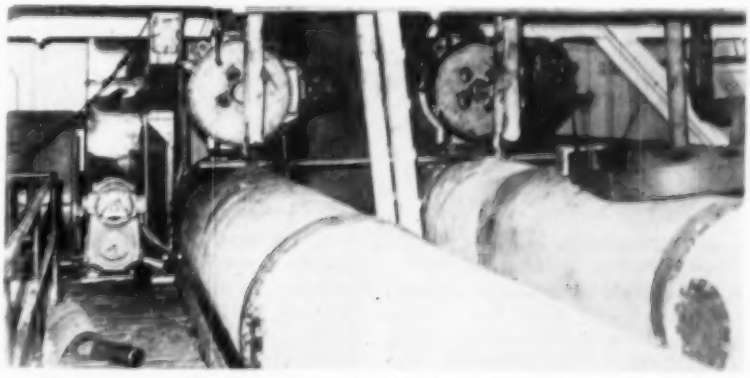


Portable Wulff process acetylene pilot plant, illustrating general type of unit referred to for pulping in forest. (Courtesy Lummus Co.)



Lower part of Great Northern log-cooking digester, showing hydraulic mechanism for quick opening door at bottom of cylinder. (Courtesy Great Northern Paper Co.)

Bauerite Process Rapid Cycle digester at Gould Paper Co., Lyons Falls, N. Y. Note quick-opening discharge valve at base. (Courtesy Bauer Bros. Co.)



Continuous digesters at Coos Bay Lumber Co., Coos Bay, Ore. Feed valves shown. Unit known as Bauer-Grenco type. (Courtesy Bauer Bros. Co.)

contributions of
CHEMICAL ENGINEERING
to pulp & paper technology

Joseph L. McCarthy | University of Washington, Seattle, Washington

Major progress has been made in the pulp and paper industry in recent years and further advances are in the making. These developments take place as a result of contributions and influences from many individuals and fields. However, with respect to chemical engineering, some changes may be recorded:

• **Growth of the chemical engineer's viewpoint:** Perhaps most striking is the shift away from the viewpoint that the pulp and paper industry is a finished stable art and toward the viewpoint that it is a dynamic expanding economic unit in which engineers and scientists play a significant role in helping to create improved and new processes and products.

• **Growth in engineer-scientist personnel and development facilities:** Engineering and scientific personnel are steadily being brought into the industry in spite of the short supply in these fields. B.S., M.S. and Ph.D. graduates (especially in chemical engineering, chemistry, and mechanical engineering) are taking up posts all along the line in production operations, process or product development, and pilot plants and pioneer research activities. Appropriate development and laboratory and library facilities are maturing correspondingly. Plant instrumentation and statistical treatment of data has greatly increased. High speed computing machinery and the operations research approach are in use in some companies.

• **Use of magnesium and ammonia base sulfite pulping:** Although calcium bisulfite with sulfurous acid in water solution has, for the last eighty years, been in general use in the "sulfite" process for dissolving lignin from wood to produce cellulose fibers, magnesium bisulfite or ammonium bisulfite processes have recently replaced the calcium base process to a significant extent. In the magnesia process (plants at Longview and Grays Harbor, Washington and at Ketchikan, Alaska) spent liquors are collected, evaporated, and burned under such conditions that useful steam and most of the process chemicals are recovered. In the ammonia process (now perhaps fifteen or twenty per cent of the U. S. "sulfite" capacity), lignin removal proceeds more rapidly and a wider variety of wood species can be handled, but no good ammonia recovery process is so far available. In the course of these developments, major chemical engineering operations were concerned with washing and filtration, evaporators and condensers, furnaces, absorption towers, cyclones, etc.

• **Development of continuous pulping processes:** The closely controlled conditions required for lignin removal to produce good quality wood cellulose pulps have generally been achieved by use of batch reactors or digesters. However, in the last five years or so, marked advances have been made in the design and operation of continuous digesters offering better heat economy and possibly lower labor and capital costs. Several continuous kraft pulping installations (sodium hydroxide-sodium sulfide solutions for lignin removal) have now been made in the U. S. and Canada and more are being considered. Other developments involve use of other process chemicals and/or mechanical defiberation. Continuous sulfite pulping so far seems still to present difficulties because of corrosion and cellulose degradation problems.

• **Development of improved bleaching processes:** Kraft pulps are much more difficult to bleach than sulfite pulps. Thus the post-war growth of kraft pulp production has been accompanied by work and achievement in the development of improved and often continuous bleaching processes. These now usually involve a chlorine gas treatment of an aqueous suspension of unbleached cellu-

existent markets. The result was a mass of contributions to the literature but few full-scale recovery systems. But today there is a growing emphasis on the study of *physical* chemistry (physical properties which will influence use) of the lignosulphonates (the chief constituents of these liquors) and on chemical engineering methods for treating the entire volume of the liquors in bulk to produce a range of chemicals for which mass markets may be found. This will not produce *many* scientific papers; but it should result in a few plants.

Careers in Chemical Engineering Almost Unlimited

The mechanically oriented engineer will certainly continue to dominate the design and process control aspects of papermaking, which is, in the last analysis, a physical operation. The materials-oriented chemist is so essential to background work in many aspects of chemical pulping and waste product utilization and even of papermaking itself, where the physical chemistry of fiber bonding is important, that his position in the industry is recognized and secure. For the obvious reason of endeavoring to interest more chemical engineers in looking to the paper and pulp industry for challenging opportunities, I have attempted to highlight the place of the chemical engineer in our industry, a role which could easily become a dominant one over the years immediately ahead because the revolutionary trends which I have identified will require his peculiar talents, his training, and his ways of thinking—his *practical* slant on things, if you will.

It has been said, on competent authority, that the pulp and paper industry of this Continent may double its production within the next 25 years. The projections behind this prediction have been based largely on growth curves of population and on curves of increasing demand for products already produced. But, when one considers the *new* products for which there may be mass markets—improved disposable dishware, disposable clothing, disposable household "linens," about which one can read in current magazine advertising, it is not difficult to imagine that the prediction will be exceeded. Combinations of cheap wood pulp fibers with more expensive synthetic fibers in nonwoven fabrics might, indeed, develop a household market of a very substantial order.

It has often been said that pulp and paper are the cheapest substitutes for other materials—glass in the milk bottle, tin in the can, wood in the crate, and so on. Perhaps, in admixtures, cheap wood pulp will replace, in part at least, the more expensive

J. L. McCarthy is co-chairman with James Hull, Crown Zellerbach, of the symposium "Chemical Engineering in the Pulp and Paper Industry" to be held June 10 at the Seattle Meeting of A.I.Ch.E. For complete program details, see page 81 of this issue.

lose fibers followed by several stages of alkaline hypochlorite bleaching and washing treatments. Special bleaching chemicals such as chlorine dioxide and others are often used as auxiliaries.

- **Diversification of paper products:** Desired properties are now being created or intensified in papers by a variety of special mechanical or chemical treatments. Some polymers, for example, serve as coating materials for papers, others provide absorbent or high wet strength properties, and still others may even be used to produce cloth-like paper materials.

- **Process effluent, by-products, and conservation:** Vigorous efforts are now being made by many pulp and paper industry executives to convert process effluents into by-products which can be recovered and sold at a profit. From kraft pulp mill gas and liquid effluents, lignin products are available and dimethyl sulfide production is now under development. From sulfite spent liquors, industrial alcohol, feed yeasts, and lignin products are being produced. However, sulfite spent liquor utilization is still very actively being developed since (in the Pacific Northwest, for example) about one billion pounds of lignin sulfonates and 250 million pounds of sugars per year remain unused as a challenge both to profit-seekers and to conservationists.

plastics for a thousand and one uses. Hence, the potential market for wood pulp is, as I see it, very bright, indeed, *provided* we have enough research and technology to meet the competition from other products.

Thus, to the chemical engineer, the pulp and paper industry represents an area which is as yet only partially manned by people of his type. It is one in which very small improvements of process or product are multiplied across such a large tonnage that the aggregate showing from technological success can be most impressive. The revolutionary developments already under way may represent careers almost unlimited for the younger members of the profession, and new fields to conquer for those whose competence is already established.

Presented at A.I.Ch.E. Meeting, Boston, Massachusetts.

It seems likely that in certain segments of the paper industry—notably pulp, container board, food board, and possibly printing papers and newsprint—there will be a period of excess capacity which might well run from late 1957 to some time during the year 1960. It is generally felt that by 1960 the basic growth factor in the economy as a whole and in the paper industry in particular will have absorbed the so-called "excess capacity" now being built.

Another factor of significance for the pulp and paper industry is that it recognizes (almost for the first time in its history) that it is now facing competition from other materials such as synthetic films, foil, plastics, new forms of glass products, non-woven fabrics, and the like. It is therefore more than likely that for a period of some two or three years the paper industry will be in a competitive period—not only with its own "excess capacity," but also with other materials which are trying to gain or regain markets now being served by pulp and paper.

A competitive market of this sort immediately focuses management attention on several needs. One need is for low manufacturing costs and for any and all technical developments which would improve efficiency, lower waste, or reduce the cost of manufacture. A second need is for technical groups and sales forces to develop new products and new markets and to find new uses and new markets for old products.

There has been a great surge of research work in the pulp and paper industry since the end of World War II and it seems reasonable to assume, therefore, that over these next two, three, or four years there will be many significant discoveries coming out of that expanded research effort. The industry looks, then, to its technical research people, its technical manufacturing people, and its sales "imagineers" to create the costs, the products, and the markets that will be essential to carry it through the competitive period of the coming two or three years.

THE PAPER INDUSTRY TODAY AND TOMORROW

George Olmsted, Jr., S. D. Warren Company, Boston, Massachusetts

Today the paper industry is the fifth largest industry in the American economy, with an annual sales volume of something over 10 billion dollars. It has also been listed as the third fastest-growing industry in America—exceeded in rate of growth only by natural gas and aluminum—with a growth of some 12% in the year 1955 and a further 5% growth in 1956. Doubtless as a result of this showing, the paper industry has been termed a "growth industry" by the investment world and, as a result, insurance companies, trust funds, and individual investors have been scrambling for its securities.

A little-known but important quality about the paper industry is that it is one of the few which has a replaceable raw material—growing trees. Also important is that the entire structure of the paper industry is based on cellulose, which is one of the lowest cost film-forming materials ever discovered, one for which there is as yet no substitute, but which in turn can substitute for many other materials.

Like air and water, paper has become an essential part of our daily living and has invaded our lives, our homes, and our market baskets to the extent that some 435 lb. of paper and paper products are consumed each year by every man, woman, and child in this country.

Table 1.—Consumption of Paper and Paper Products	
1936	15 million tons
1956	36 million tons
1976	60 million tons?

Moreover, the paper industry is the third largest consumer of chemicals in the nation. Here are some typical chemical consumptions within the industry:

Chlorine	330,000 tons per year
Clay	500,000 tons per year
Salt cake	700,000 tons per year
Ammonia	40,000 tons per year
Rosin size	80,000 tons per year

of consumption is imported, chiefly from Canada.

Printing papers are used in magazines, books, labels, catalogs, annual reports, and sales literature of all sorts and descriptions.

Business papers include letterheads, office stationery, factory forms, billing papers, duplicating papers, and the like.

So called "coarse papers" cover wrapping papers, grocery bags, multi-wall shipping sacks, gummed tapes, and similar products.

Tissue papers are primarily the sanitary field—toilet and facial tissues.

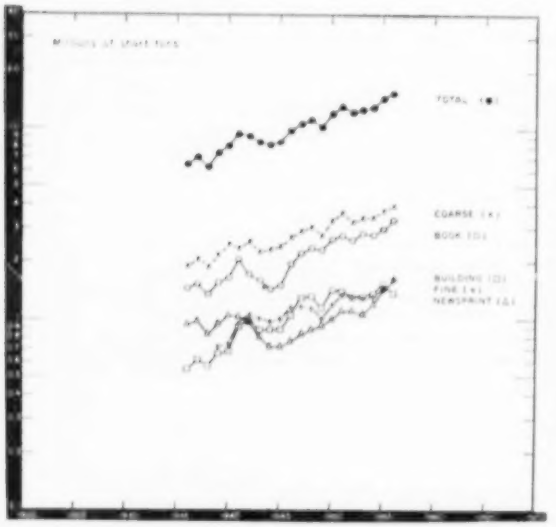
Building papers involve sheathing and roofing papers for home construction, while building board—a category down below—includes wall board panels of all types and finishes.

The largest single segment, as you can see, is board. This covers the shipping carton which is seen on every truck and freight car in the nation—the retail box such as dress boxes, shoe boxes, toothpaste boxes, and the like—and also the so called "food board" for cups, butter cartons, and pre-packaged or frozen foods.

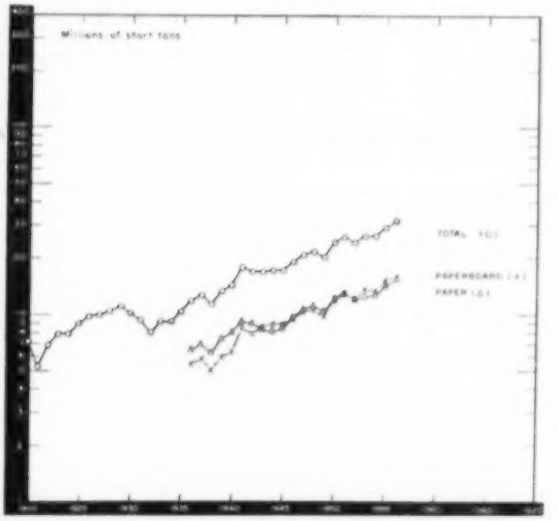
tute, the Institute of Paper Chemistry, and others, have predicted that in 1976 the consumption of paper in this country is very likely to be in the range of 60 million tons per year. Roughly speaking, this is more than a 20-million ton increase over the next 20 years—an increase in the range of 65%.

When it is realized that in the past 20 years the industry doubled in size, it seems reasonable to assume that in the next 20 years a 65% increase would be probable. (See Table 1.)

Why have there been such increases in the past? And why is it believed that we shall have such a major increase in the future? There are really four reasons for this:



Production of paper, breakdown by type.



Production of paper and paperboard.

The paper industry—usually considered as a whole—is actually a collection of segments, some quite unrelated to each other. The following list shows these segments by classes of product:

Newsprint	6.50 million tons
Printing paper	4.25 million tons
Business papers	1.50 million tons
Coarse papers	4.00 million tons
Tissue papers	1.75 million tons
Building papers	1.50 million tons
Board	14.25 million tons
Building board	1.75 million tons
Misc.	.50 million tons
Total consumption	36.0 million tons, or about 435 lb. per capita.

In the list above, newsprint, of course, is used almost exclusively in newspapers. About 25% of the 6½ million tons is produced in this country. The other 75%

This, then, is the paper industry as a whole: there are very wide differences in types of product. They range from the corporation annual reports to butter cartons, to roofing materials, to facial tissue, but all of them are a part of the paper industry and together they make the paper industry what it is today.

The Future

So much for the present! What about the future of this industry?

Various research organizations, such as the Stanford Research Insti-

The *first* is the old chestnut of our rapid growth in population. Without dwelling on this point, it stands to reason that with more people in this country there will be more school books, more annual reports, more shipping containers, more drinking cups, more facial tissue, and the like.

A *second* reason is to be found in the ability of the paper industry to have its products substitute for other products—frequently with a quality improvement and generally with a cost saving. For example, the fiber-shipping carton has substituted for the wooden case, multi-wall sacks have substituted for textile bags in the packaging of sugar, chemicals, fertilizers, and a host of other products. Facial tissue has substituted for a textile handkerchief, while wall-board panels have substituted for actual wooden sheathing.

A *third* reason for the industry's rapid growth—both past and future—is to be found in the new uses for paper, and examples of this are the packaging of frozen foods and vegetables, the pre-packaging of meats, and there is now a distinct possibility that throw-away paper clothing for industrial and hospital use will open up a wholly new market.

And the *fourth* reason for this growth lies in convenience. We are essentially a lazy people and if we can get paper milk bottles which can be burned rather than returned, if we can buy disposable facial tissues, if we can have prepared and pre-packaged foods, and even prepared and pre-packaged whole meals—all these factors of convenience are what the American public is looking for and will buy in accelerating quantities.

It is for these reasons that the past in the paper industry has been so bright and it is for these reasons that the future looks equally rosy.

Problems to Be Faced

But it will not be as easy to realize this glowing future as it is to predict it, because management in the paper industry is confronted with some very real problems. Of these problems probably three transcend all others in importance.

The first has to do with the basic raw material—wood, or trees which are growing in the forest.

Where is the industry going to get enough wood? And how can the wood supply be extended so that we will have enough raw material for the 60-million ton future that is predicted?

Fundamentally, research must give us the answer to this problem. It must tell us how we can minimize fire losses and insect and disease losses which today consume millions of cords of wood annually—millions of cords which should be put to a more constructive use. Research must tell us how to use a much greater quantity of hardwood along with the soft wood which we are now using and a much greater quantity of the clay pigment which is used as an extender. We badly need resins or other synthetic strength-giving binders which would permit a broader use of these other "not-so-scarce" materials. Research must tell us how to use more waste wood—meaning the off cuts in sawmill operation and the limbs of trees which are now largely going to waste. And finally, long-range, much must come from very fundamental research on forest genetics, which means the actual breeding of trees so that ultimately there will be more fiber per tree and more trees per acre.

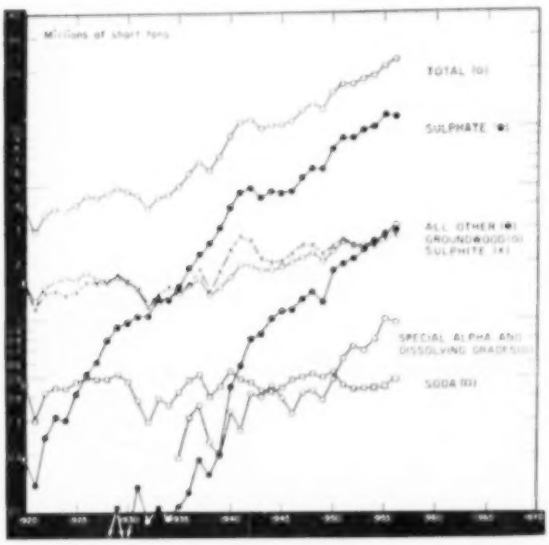
A second problem which paper industry management faces today is the problem of getting money for expansion of facilities.

A paper mill today costs somewhere in the neighborhood of $450 to $500 per annual ton of production. This figure is a significant one, because we have been reading lately that a steel mill costs about $300 per annual ton. So, for a rough rule-of-thumb, it can be safely figured that an integrated paper mill costs at least half again as much as a steel mill.

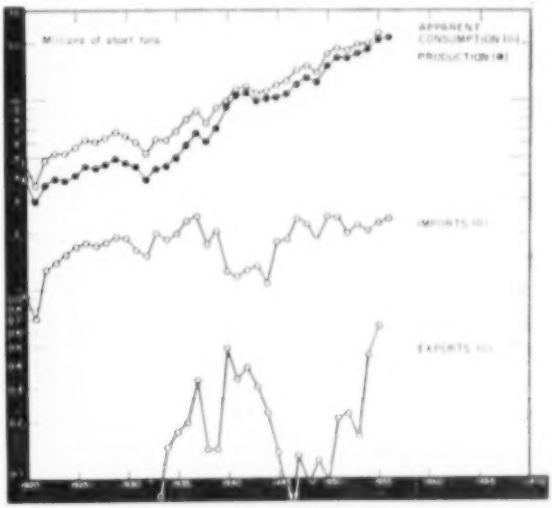
If the industry has 20 million tons or more of new capacity to build in the next 20 years, it therefore means an expenditure of something over 10 billion dollars. This, of course, is an enormous sum and a very large part of this money must come from profits retained in the business. This is what the steel industry has been talking about for the past year or so. The pulp and paper industry has precisely the same problem, and so one of management's constant worries today is the cost-price relationship in the industry or, to put it another way, how much profit can be retained for future expansion.

The *third* problem to face is the problem of manpower—a problem not unique to this industry.

(Charts on these pages courtesy Stanford Research Inst., *Chemical Economics Handbook*.)



Production of wood pulp, breakdown by process.



Salient statistics on wood pulp, all grades and types.

This is a double-barreled problem, for we face not only the necessity of replacing older people, but also of building up our organizations to take care of a 65% increase over the coming 20 years. There is a great need for men with the proper background and training not only for sales and administrative functions, but primarily technical manpower for production and research.

Paper-making is both a chemical and a mechanical operation. Over the past generations far too much emphasis has been placed on the mechanical phases of paper-making and far too little on the chemical possibilities. But this situation is changing very rapidly and there is an almost unlimited opportunity for chemical engineers today to do a constructive and satisfying job in the paper industry.

Presented at A.I.Ch.E. meeting, Boston, Massachusetts.

CHEMICAL ENGINEERING'S ROLE IN THE DEVELOPMENT OF PULP AND PAPER TECHNOLOGY

*Roy P. Whitney** | The Institute of Paper Chemistry, Appleton, Wisconsin

The modern pulp and paper industry is a far cry from that of even a few decades ago. Previously, it has been said that developments during the past one hundred years have far surpassed those of its previous eighteen centuries! Today the industry is successfully undergoing the painful transition from an art to a science, a process which has proved difficult to many old industries. Having already emerged as a vigorous chemical process industry, looking to the future rather than to the past, the industry offers challenges which will require the best efforts of competent scientists and engineers.

A curious fact about this industry, which may be not entirely without significance, is that its emergence as a chemical process industry has roughly paralleled the development of the profession of chemical engineering. Both had their initiation at about the turn of this century, both underwent two or three decades of accelerating growth marked primarily by empiricism, and both are today making great strides toward a sound scientific basis and understanding. It is doubtful that these drastic changes in the pulp and paper industry are appreciated by many technical men, beyond the relatively few who have brought them about. There is little doubt, however, that the further changes necessary to put the industry's technology on a firm scientific footing will require a close union with the concepts and techniques of chemical engineering. Because of this, the means by which the chemical engineer's contribution can be directed toward and then brought to bear on both the research and development needs of the industry's technology will be the subject of the remainder of this article.

Type of Education Required

The most vital contribution which can be made to the science or engineering student's development is to help him gain a sound understanding of the basic physical and chemical principles involved. These principles transcend specific situations, and provide the basis on which the particular problems of any industry can be addressed, whether in anticipation of professional work in the pulp and paper industry or any other process industry.

The chemical engineering field is a difficult and exacting one. Requiring, as it does, a thorough grounding in chemistry, physics, and mathematics before serious professional work in the field is initiated, the undergraduate curriculum is already crowded and the time actually spent in chemical engineering courses is at a minimum. This is one of the major reasons why graduate work in chemical engineering is so important. It also helps to explain the present growing interest in five-year programs, particularly where specialized application, for example in the pulp and paper industry, is desired.

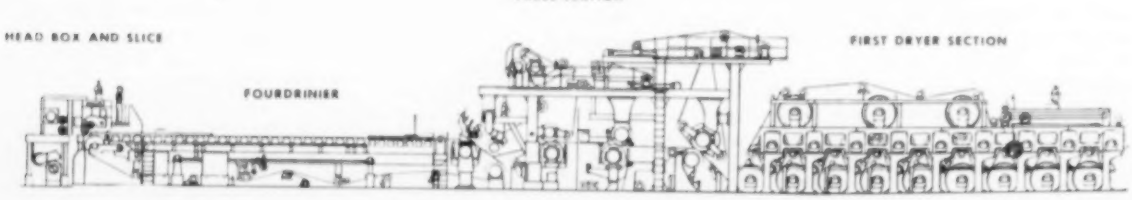
The principles of chemical engineering are broadly applicable; are equally as applicable to the problems of the pulp and paper industry as to those of any other. It should not be minimized, however, that difficulties and pitfalls will confront the chemical engineer as he attempts to apply his principles to the practical problems of this industry, but the industry will provide a fertile field for the further development of these principles, through new theories and hypotheses to final useful relationships, in directions which will help to resolve problems outstanding for centuries.

To the student, these vital principles do not become alive and meaningful until he has developed a facility in utilizing them in practice, and often this is the most difficult and challenging phase of his education. It is in this phase that specific situations and problems, drawn largely from industry, become essential. Certainly, the pulp and paper industry offers a multitude of these chemical engineering situations and problems capable of challenging both the teacher and the student to the limit of their capacities. The use of these situations and problems can be carried further at the graduate level—particularly as regards the development of new information, hypotheses, and theories—helping bring about the advancement of the chemical engineering field through the usual combination of education and research.

Jenness, elsewhere in this issue, in discussing manpower needs for the industry, refers to undergraduate curricula which stress pulp and paper technology. His own institution has been truly a pioneer in recognizing the importance of chemical engineering in the pulp and paper industry, and in translating that recognition into concrete accomplishments in teaching and research, at both undergraduate and graduate levels. Other educational institutions have offered grad-

* Roy Whitney is Dean of the Institute.

Artist's drawing of new 276-inch Beloit paper machine being built for Great Northern Paper Company's E. Millinocket, Maine mill. Approximately 375 feet long, the machine weighs 2,500 tons, can operate at speeds up to 2,500 ft./min.



uate courses and have undertaken chemical engineering research in fields pertinent to the pulp and paper industry. In several instances, these institutions are located geographically with respect to important concentration of the wood-using industries, as for example the Universities of Washington and Florida. The Massachusetts Institute of Technology, by locating one of the field stations of its School of Chemical Engineering Practice in a pulp and paper mill, has been actively engaged in this area of teaching and research for nearly forty years.

One of the recognized centers for the education of men for positions of responsibility in the pulp and paper industry is The Institute of Paper Chemistry. This is a private institution, supported largely by the pulp and paper industry of the United States. Because of the importance of chemical engineering in its program, and because its educational philosophy illustrates a point of view which is worth bringing out, the Institute's program will be described briefly.

The Institute believes it can best fulfill its function through a rigorous and thorough training of its students in the fundamentals of the physical sciences and the technologies which underlie the industry. The educational philosophy of the Institute is further expressed in the development of "scientific generalists" rather than specialists in any of the several branches of science and engineering.

The growing importance of highly-trained specialists in our increasingly complex society is recognized, but at the same time, and in fact partially because of this trend, the need for more broadly-trained individuals who are competent to correlate, interpret, and to range across the several fields of science in their thinking and their research becomes more acute. This concept of broad experience, now gaining rather widespread recognition, is one in which the Institute, even over its short life span of 27 years, has been a pioneer.

Connecting Link

It has been mentioned that chemical engineering occupies a key position in the Institute's academic and research programs.

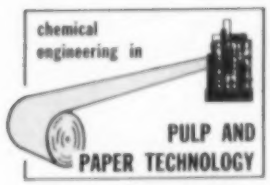
Chemical engineering is the function that must provide the essential connecting link between the pure scientists on the one hand and the pulp and paper industry itself on the other. It must work in close co-operation with others in contributing the powers of the chemical engineering discipline to the solution of the broad problems which cut across the several fields.

As we grow in understanding, we lean more and more to the viewpoint that few, if any, important scientific and technical problems are confined to one single field of science or engineering. As an example of the interrelationships among the various disciplines, consider one of the unsolved problems facing the pulp and paper industry: the development of an adequate basis for the design and operation of digesters or other equipment for the pulping of wood. The problem would seemingly fall largely in the chemical engineering field, involving particularly considerations of reaction kinetics and heat and mass transfer, but exploration further into its basic nature will show a more complex pattern to be a basis for further development.

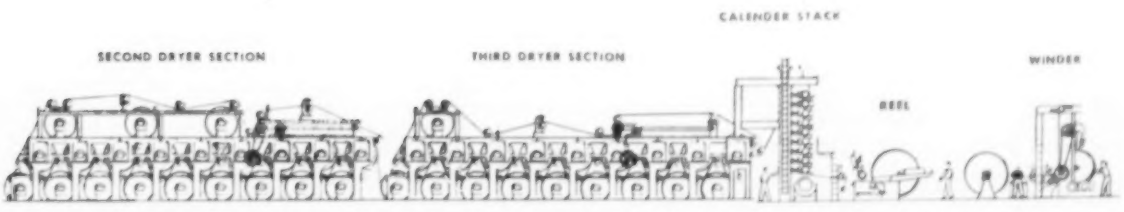
It should be brought out that recognition of the importance of the problem of digestion is in itself an important indication of the changing nature of the industry. Digestion has been no great problem in the past.

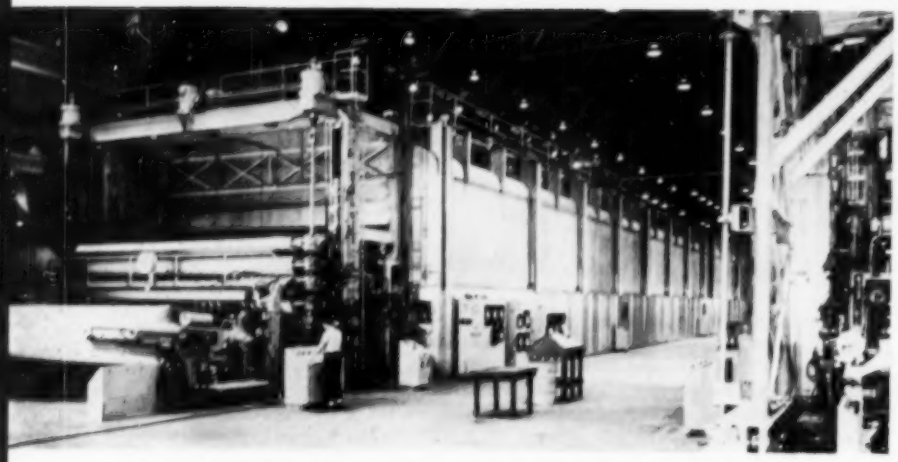
Wood was considered to consist principally of cellulose and lignin, and the approach was to dissolve the lignin and leave the cellulose unattacked. Certain reagents were known which would do this, to a greater or lesser extent, and all one needed was a large pressure autoclave in which to conduct the reaction. An unbleached pulp yield of about 48 to 50% of the original wood should be expected.

Such an oversimplified point of view is no longer adequate. Wood does not consist simply of cellulose and lignin, but is a complex mixture of compounds. Some or all of these compounds may or may not be desired in certain grades of paper. Cellulose is not a simple compound, but is a highly-complex polymeric material which may vary widely in both physical and chemical properties, and which may react with pulping reagents and be itself reacted upon in a variety of ways. The pulping process and the resulting pulp must be tailored to the end use, and the pulp yield from the wood may be anywhere from about 35 to nearly 100%.



How, then, shall we approach our problem? Obviously, we must learn from the pulp and paper technologist the details of his end use requirements. We need much information from the wood chemist regarding the details of wood composition. We must work with these and other colleagues in attempting to relate end use requirements with wood and pulp composition and physical structure. Although this is now possible only in a most elementary way, perhaps we can learn to define our problem in terms of those components to be removed, those to be altered or partially removed, and those to be left unattacked. And now we need much assistance from the organic chemist. The structure and reactivity of the various wood components toward possible reagents must be studied, and reaction conditions established which will at least approach the selectivity we desire. Perhaps now we can begin to consider the kinetics of the desired reactions, but work in this area is seriously handicapped by the lack of adequate analytical methods with which to follow the progress of the reactions. Further than this, we are dealing with heterogeneous systems, and the spatial configuration of the solid phase is not within our control. The wood technologist can aid us here with his work on wood structure, and on the occurrence and location of the various components within the tree. It may not be too fanciful to suggest that the forest geneticist, who is hard at work in this area, can help us by making certain components more "available" to our reagents in the trees of the future.





View of one of the Fourdrinier paper machines at the E. Millinocket mill of Great Northern Paper.

The pulp and paper industry will need, by 1965, from two to three times the number of chemical engineers it now employs—a situation resulting not only from increased use of paper products, but also from the continuing evolution of new processes in the idustry.

*L. C. Jenness**

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University of Maine, Orono, Maine

Of approximately 650,000 engineers in industry, government, and education only 4,000 (or less than 1%) are employed in the pulp and paper industry (*1*). The number of chemical engineers among those 4,000 is not known, but if the percentage is as high as 50% it would provide an average of only about *two* chemical engineers for each of the more than 900 pulp or paper mills in the United States, although several companies are known to have a number of chemical engineers in their employ.

In 1955 the National Science Foundation interviewed 200 employers of research scientists and engineers regarding the shortage of this type of manpower. One third of the companies interviewed reported acute shortages of major proportions and this group included "all or most" of the paper companies interviewed.

It is probable that these 4,000 engineers do not include graduates with a B.S. degree in Technology from the University of Alabama, North Carolina State College, New York State College of Forestry, Western Michigan College, Lowell Technological Institute and the University of Maine, which have undergraduate curricula in pulp and paper technology but are not accredited, however, as of professional engineering status. Although having served as a major source of supply of technologists for the pulp and paper industry, these six schools together graduate but a few more than 100 men per year. This number is now hardly adequate for replacement of those who retire and certainly inadequate to provide for the expansions of research, development, and production in the industry.

The demand for professional chemical engineering graduates is evidenced, on the other hand, by the extent of interviewing on college campuses. At the University of Maine, where a five-year program not only meets ECPD requirements for a B.S. in Ch.E. degree, but also provides extensive course

Admittedly, I have chosen a most difficult and involved problem to discuss. But it is an important problem, and it is encouraging to note that progress is being made toward at least a partial solution. The problem was chosen to demonstrate the interdependence of fields and to emphasize the point that, with such a problem, a group of research men representing several disciplines can hope to progress much more rapidly than could an individual or a group representing only one discipline.

Obviously, not all problems cut across the boundaries of disciplines to the extent shown by this example. Much chemical engineering research is proceeding, and much more is needed, on problems which fall essentially within this field. Research and development chemical engineers, working in or on behalf of the pulp and paper industry, have contributed significantly to the "chemical engineering science" approach, and have in turn used the newer concepts in their applied research and development studies. As a result, rapid and significant progress is being made toward a better understanding of present industrial operations and development of new, improved techniques for the future.

A case in point is the Fourdrinier paper machine, a device which is old in basic concept, but which is still undergoing rapid development. A modern Fourdrinier machine continuously converts a dilute fiber slurry into a dry paper sheet, of width up to twenty feet or more, and at speeds approaching and sometimes exceeding one-half mile per minute. The Fourdrinier is a complex mechanism which may be a city block in length, but it is in essence a device for conducting two chemical engineering unit operations—filtration and drying.

Theories of the filtration of slurries which yield compressible mats are in their infancy. Much progress has been made recently, however, and this has come largely from the pulp and paper field. It has been possible to characterize and to elucidate the nature of the highly compressible cellulose fiber mats, and thence to predict their behavior on a paper machine. Working more specifically with the mechanical devices presently in use, other researchers have succeeded in developing the fundamental relationships governing the driving forces causing filtration, and in demonstrating their applicability on commercial installations. Thus, significant progress is being made toward fundamental insight into the filtration stages of papermaking.

Hot-surface drying of thin sheets is another poorly-understood operation. Here, as in the case of filtration, our present limited understanding of drying as a chemical engineering unit operation proves to be inadequate to meet the needs of the industry's future development. Studies of the mechanisms of both heat and mass transfer, approached in part through internal sheet temperature distributions and internal movements of both liquid water and water vapor, have thrown much light on the operation of hot-surface drying. The results have already proved to be valuable, but much remains to be done.

Chemical engineering research and development aimed particularly at the problems of the pulp and paper industry have been proceeding for many years. The results have been most impressive, and the rate is increasing rapidly. The opportunities for future contributions will be limited only by the capacities of those who accept the challenge.

Presented at A.I.Ch.E. meeting, Boston, Massachusetts.

* L. C. Jenness is head of the Department of Chemical Engineering.

Chemical Engineering MANPOWER for the Pulp and Paper Industry

work in pulp and paper technology, 88 pulp and paper companies last year interviewed 23 graduates who sought placement in this or allied fields.

These courses include the theory and practice of pulp and paper technology, pulp and paper mill equipment, mill visits, mathematical statistics, and several courses in economics and business administration. This five-year program is open to all engineering undergraduates but is taken mostly by students of chemical engineering and mechanical engineering. The enrollment in this five-year program would doubtless be much smaller if it were not for the fact that scholarships and grants are available to these students from The University of Maine Pulp and Paper Foundation. This Foundation is composed of over 70 companies involved in the production of paper or supplying the paper industry with materials and equipment.

Many chemical engineering graduates of other schools enter the pulp and paper industry. Some of these will have had special training for the industry, other than that previously mentioned, such as the excellent practice course provided by the Massachusetts Institute of Technology.

To predict the number of chemical engineers that will be in demand by the paper industry in 1965 is virtually impossible. Increased demand, however, will not be due solely to the increased use of paper products, which has increased exponentially over the last forty years, but will be due to an even greater degree to the continued evolution of the processes from the practical arts to a highly scientific and modern technical basis. The author predicts that the demand in 1965 will be from two to three times the current demand, even though the latter cannot be specified in numbers.

It seems obvious, therefore, that this demand for chemical engineers can be met only by enlisting more such graduates from colleges and universities than are now servicing the paper industry. On the other hand, the author doubts if young chemical engineers can receive necessary orientation as to the potentials and future needs of the industry from the industry itself. The only solution obvious to the writer then, is to encourage more students to study chemical engineering with the specific purpose of applying it to the pulp and paper industry, taking selected undergraduate or postgraduate courses to achieve this orientation.

What about the chemical engineer already experienced in the practices of the chemical and petroleum refining industries? Can he expect to find a challenging field for his ideas in the pulp and paper industry? This question was raised during the panel discussion which was part of the Pulp and Paper Symposium at the Boston A.I.Ch.E. meeting. In reply, an industry executive answered, "emphatically yes." To which this writer would like to add his own affirmation—provided the subject chemical engineer has sufficient latitude for exploration and closeness of contact with management.

Chemical Engineering Application to the Industry

The production of pulp and paper provides an opportunity to apply as many, if not more, chemical engineering principles and unit operations than exist in any other industry. As substantiation for this statement consider the following examples: major modifications of the basic processes are now necessitated by increasingly competitive economics and by the use of new types of wood necessary to meet the growing demand for paper products.

One of these modifications is the increasing use of semi-chemical pulping of hard woods which allows higher pulp yields, but requires changes in pulping procedure, subsequent treatment of the pulp, and some modifications of recovery of heat and chemicals from the used cooking liquor.

Another recent innovation is semi-chemical cooking of whole sticks of wood prior to grinding into groundwood pulp (*2*). This operation is conducted in automatically operated batch digesters that hold approximately 25 cords of wood. Control of temperature, pressure, and mass transfer by diffusion are essential to the production of uniform pulp.

A large number of other recent engineering developments could be cited, such as the pressure head box for distribution of pulp stock to paper machine wires, increased speed of paper machines (now on the order of half a mile per minute), new methods of applying coatings and new types of coating, filled and reinforced papers, and a host of different types of paper for specific end uses such as those required by the packaging field. Recent contributions to the industry's technology include beta-ray gauge measurement of moisture content of the sheet as it passes through the machine and exploitation of the compression-effect evaporator for concentrating waste liquor.

Increased emphasis on research by both industry and schools is encouraging. For many years the industry has not compared favorably with other industries in this regard, but the situation is improving. The larger paper companies now have excellent research facilities and either directly, or through associations, are sponsoring research at schools, much of which is very fundamental.

The pulp and paper industry today promises a challenging future for the chemical engineer. To take advantage properly of this opportunity, early preparation as to the specialized needs of the industry should be undertaken by the individual—whether student or seasoned engineer.

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Presented at A.I.Ch.E. meeting, Boston, Massachusetts.

A fuller appreciation of this treatment of the subject of linear programming in operations research applications will be gained if it is read as a complement to Richard Ackoff's Introduction to Operations Research which appeared in the January, 1957 issue of *CEP*.

LINEAR PROGRAMMING

as a tool for the solution of management problems

A. Charnes
W. W. Cooper

Purdue University, Lafayette, Indiana
Carnegie Institute of Technology, Pittsburgh, Pennsylvania

Part of the research underlying this paper was undertaken for the project *Planning and Control of Industrial Operations* at Carnegie Institute of Technology and part for the project *Methodological Aspects of Management Research* at Purdue University. Both projects are under contract with the Office of Naval Research. Reproduction of this paper in whole or in part is permitted for any purpose of the United States Government. Contract Nonr—760—(01), Project NRO47-011 and Contract Nonr—1100—(05), Project NRO47-016.

Management problems typically occur in non-laboratory contexts and involve a large number of variables and relations which need to be considered. OR methods employed for their solution may nevertheless be characterized as "scientific." In fact, this extension of the scientific approach has been made possible because of basic methodological advances which have been made in recent years.

One of the new tools that has come into prominence in solving complex management problems is "linear programming." For reasons which (it is hoped) will shortly become apparent, it is possible to discuss this one tool in a way which illuminates other tools and the whole OR approach as well.

As Ackoff has noted (*1*), the use of mathematical (or other abstract) models is typical in OR work. Such models have, of course, long been employed in almost every branch of science. Their use becomes almost indispensable in a field such as OR, which must work far beyond the confines of controlled laboratory conditions. The example discussed in this paper is only one of numerous models. Drawn from the field of factory operations, it will be used only to show the nature of OR problems and the kind of models used to attack them.

Other examples could be drawn from areas such as petroleum refining, mixing animal feeds, setting market quotas, transporting freight, determining patterns of executive compensation, and numerous other areas. A variety of such models and related methods of solution are now available. Deeper analysis has suggested, however, that all of them may simply be composites of a few fundamental types. It is not necessary to enter into this subject here since this is a matter of research interest in management science* rather than a matter of immediate application to practical problems. The topic is mentioned only to suggest that even the example which will be discussed may not be as restricted as the management context in which it occurs might suggest.†

The example to be used, drawn from the area of planning machine loads in a factory, [see, e.g., (*4*)], is an artificial and highly simplified example which is intended for illustration rather than application.

The expressions appearing in Table 1 constitute a "dictionary" which attempts to relate the symbols and language of mathematics to the language of business.

The mathematical relation here specified is one which is familiar from elementary algebra. It might be employed to answer the following business question: If 12 hours of capacity are available on a certain machine, how many units, x, of a certain product can be produced at 3 hours per unit? The answer is apparent: $x = 4$.

This equation, $3x = 12$, is also called a "constraint." It is a particularly severe constraint since it allows no choice. Hence, the use of the word *program*, drawn from the language of management, is somewhat awkward. It will nevertheless be used to describe all such solutions to constraint relations.

* A formal definition of management science will not be ventured. The relations between OR and management science are roughly comparable to those which exist between, say, chemistry and chemical engineering. An invidious comparison is not intended since applications are vital to progress in scientific research and vice versa.

† See Literature Cited (*2*) for further discussion.

Suppose the expression in Table 1 is replaced by

$$3x \leq 12 \qquad (1)$$

The inequality symbol ($\leq$) now allows a range of choices. Any number may be inserted in place of x in order to obtain a program, provided the resulting multiplication (by the 3 hours of processing time) does not yield a number which exceeds the 12 hours of available capacity. Of course, negative numbers are not allowed since these will ordinarily not have any meaning.* Mathematically, this is stated by the non-negativity requirement

$$x \geq 0 \qquad (2)$$

on all solutions. A value of x which satisfies (1) and (2) is said to yield a feasible program: $x = 0$, 1, 2, 3, and 4 are examples.

Suppose now that the model is broadened in the following manner. Two products are to be considered as candidates for loading on each of two machines: M_1 and M_2. The first product must be processed on both machines, requiring 3 hours on M_1 and 5 hours on M_2, while the second requires processing only on M_1. That is, the second product requires, say, 2 hours on M_1 and none on M_2. If M_1 has 12 hours of available capacity and M_2 has 10, the resulting model can be portrayed as in Table 2.

This model is still far too simple to reflect an actual business problem. It can, of course, be extended in a variety of ways. More machines and products can be included without difficulty. If necessary, non-technological aspects can also be brought in. For example, the firm's policy may require a certain balance between the two products. E.g.,

$$x_2 \geq x_1$$

or

$$x_1 - x_2 \leq 0 \qquad (3)$$

* In certain problems involving inventory accumulation, for example, such negative numbers may be allowed.

Table 1

Mathematics		Management
$3x = 12$	equation or constraint	condition
$x = \frac{12}{3} = 4$	solution	program or schedule

may be used to indicate the firm's preference for producing the second product. Alternatively, the schedules may need to be set in terms of existing market relations as when, for example, the two products are used in conjunction with each other. Thus,

$$x_2 \leq 3 + x_1$$

or

$$-x_1 + x_2 \leq 3 \qquad (4)$$

states that, say, 3 units of replacement demand for x_2 will occur but further sales of this product are contingent upon sales (and hence production) of x_1 as well.*

The bottom portion of the expressions in (3) and (4) are mathematically in the same form as the constraints shown in the upper left-hand corner of Table 2. To avoid excess terminology, all of the right-hand constants are referred to as "stipulations." Whether embedded in technology, laws of physics or society, management policy, union contract relations, etc., they are conditions stipulated in advance. All programs must conform to these stipulations if they are to be feasible.

The inequalities of Table 2 are "linear." They can be equivalently represented by the following pair of equations:

$$\begin{aligned} 3x_1 + 2x_2 + y_1 &= 12 \\ 5x_1 + y_2 &= 10 \end{aligned} \qquad (5)$$

with $y_1, y_2 \geq 0$. (Here the variables with zero coefficients are omitted to simplify the presentation.) These variables (y_1 and y_2) are called "slack." Non-zero values for these variables indicate the amount of idle time—i.e., the amount of capacity which will not be utilized in a particular program. Three possible programs are presented at the bottom of Table 2. The first programs $y_1 = 6$ and $y_2 = 0$ so that six hours of slack will appear on M_1 and none on M_2. The second program yields $y_2 = 10$ and $y_1 = 0$, while the third provides no slack on either machine so that both are used to capacity.

* Notice that contradictions may emerge so that management reconciliation of conflicts between policies, technological requirements, etc., may be required. Isolation of such conflicts is one task of OR applications.

Objectives

In the present example the programs (i.e., solutions) were obtained by inspection. In large problems they might be obtained by simulation on an electronic computer using the "Monte Carlo" routines described by Ackoff (*1*). After a sufficient number of solutions is obtained they might be examined and one of the candidates thus generated accepted as a preferred choice.

Alternatively, an objective and related criteria of choice might be specified in advance. This leads to so-called optimizing models of the linear programming variety.

Suppose, for example, that each unit of x_1 yields a profit (above variable cost) of \$1.00 and each unit of x_2 returns \$.50. These are the criteria. The objective is to maximize this net return. Mathematically,

$$\$1.00\ x_1 + \$.50\ x_2 \qquad (6)$$

states the relevant criteria of choice and the instruction to maximize this "linear form" prescribes the objective.

Table 2

Mathematics		Management
M_1: $3x_1 + 2x_2 \leq 12$ M_2: $5x_1 + 0x_2 \leq 10$	Technological constraints	Plant and product conditions
$x_1, x_2 \geq 0$	Non-negativity constraints	Only meaningful programs will be considered.
$x_1 = 2, x_2 = 0$ $x_1 = 0, x_2 = 6$ $x_1 = 2, x_2 = 3$	Feasible solutions	Possible program choices

Notice that (6) is not "pinned down" in any manner. Any values may be assigned to these variables. It differs, therefore, in an important respect from the constraints, such as (5), even though it has the same "form," mathematically speaking.

Of course, the values selected for x in reaching the objective must conform to the constraints set forth in Table 2. It is these constraints which limit the degree of accomplishment. Table 3 further extends the dictionary, to give a complete statement of the linear programming problem for this special case.

In optimizing models (of which linear programming is an example) the objective and related criteria must be specified in advance. The methods of analysis must then be able to single out the best solution. (Notice that this feature is absent in simulation models since there is, in general, no guarantee that the region in which the best solution lies will necessarily be explored.)

To be sure, too strong a contrast between the two approaches should not be drawn. Simulation and optimization are usually complementary. In addition, major interest may attach to the study of a range of possibilities rather than the selection of one best program. It should be noted, however, that the methods of linear programming can be extended to the location of alternate programs, second-best programs, third best, and so on. They may also be used for handling conflicting objectives of the kind found in the theory of games or multiple objectives of the kind found in decentralized organizations where managers in different divisions do not necessarily have the same objective. These topics are covered in the literature (*2*) and will not be pursued further here. It will be sufficient to close this part of the discussion with the following formal definition: Mathematically speaking, the problem of linear programming is to optimize (*optimize* is intended to cover objectives which involve minimizing as well as maximizing) a linear form subject to a set of linear constraints—viz., optimize

$$\sum_{j=1}^{n} c_j x_j = c_1 x_1 + c_2 x_2 + \ldots c_n x_n$$

subject to

$$\sum_{j=1}^{n} a_{ij} x_j = a_{i1} x_1 + a_{i2} x_2 + \ldots + a_{in} x_n \leq b_i$$

$$x_j \geq 0$$

$$j = 1, 2, \ldots, n$$

$$i = 1, 2, \ldots, m,$$

where the x_j represent n variables to be programmed, the c_j are criterion elements (such as unit profits), the a_{ij} are constants (such as the machine processing times) and the b_i are stipulations (such as the machine capacities). General methods are available for solving any such problem * and further progress is being made in devising highly efficient methods for dealing with significant special cases.

Dual Problems

The preceding characterization has perhaps emphasized unduly the linear character of the models and methods of linear programming. In recent years considerable progress has been made in devising computationally practicable methods for a wide variety of non-linear problems [see references in (*3*)]. Instead of entering into a technical discussion of these methods, it will be useful to turn to other aspects of linear programming in order to show how these methods can be extended to other kinds of management problems with which OR is concerned.

Management is often interested in the advantages that might attend an alteration in one of its policies or an expansion in its facilities. Consider the following typical example: What return, at going market prices, might be expected if M_1 and M_2 capacity were each increased to 15 hours instead of their present levels of 12 and 10 hours, respectively? The methods of linear programming, it so happens, automatically supply an answer to questions of this kind as a by-product of answering the direct programming problem initially stated.

Let w_1 and w_2 represent variables which are intended to provide an evaluation (in terms of total profit) for each hour's increase in the available capacity of M_1 and M_2, respectively. Here an evaluation of the stipulations is wanted so that

$$w_1 b_1 + w_2 b_2 \qquad (8)$$

provides the correct evaluation per unit alteration, starting with $b_1 = 12$ hours on M_1 and $b_2 = 10$ hours on M_2.

This expression is a linear form constructed from the data (machine capacities) of the original problem stated in Table 3. The other data, such as the machine processing times and the unit profits, must also be considered in order to answer such a question. These considerations are placed in evidence by the following "dual problem" which utilizes the same data as the original problem, simply altering their arrangement and restating the objective and the criteria:

minimize: $12\ w_1 + 10\ w_2$

subject to

$$\begin{aligned} 3\ w_1 + 5\ w_2 &\geq \$1.00 \\ 2\ w_1 &\geq \$\tfrac{1}{2} \\ w_1, w_2 &\geq 0. \end{aligned} \qquad (9)$$

Every process, every product, and every machine, as well as the going market returns, are therefore marshalled in this dual to the direct model shown in Table 3.

Consider, now, the solution to (9). Simple inspection shows it to be $w_1 = \$.25$ and $w_2 = \$.05$. Substituting these values into the linear form exhibited in (9) yields the total $12(\$.25) + 10(\$.05) = \$3.50$, the same as the return secured for the direct problem stated in Table 3. This is no accident. It is an illustration of a powerful theorem of linear programming known as the dual theorem, which states that the maximum of the direct problem must equal the minimum of its corresponding dual.

This duality was first conjectured by John von Neumann and later stated ex-

* See, e.g., (*3*). This definition is the "classic" formulation due to G. B. Dantzig (*6a*). Although unduly restrictive, it does have the virtues of simplicity and relevance.

plicitly and validated by D. Gale, H. W. Kuhn and A. W. Tucker. See (*6c*). An alternate presentation may be found in (*6b*).

This theorem has more than mathematical power and elegance to recommend it. It can be used for many purposes, including the detection of contradictions of the kind noted in the footnote to Equation (4) above. By means of this theorem it is possible, for example, to secure an answer to the question on facilities alteration which was posed above. Let the values $b_1 = 12$, $b_2 = 10$ be replaced by $b_1 = 15$ and $b_2 = 15$ in (9). At the values * $w_1 = \$.25$ and $w_2 = \$.05$ (which remain an optimizing solution to the problem thus altered) the return should be 15 ($.25) + 15 ($.05) = $4.50—a $1.00 increment over the preceding level. The dual theorem states that this will be the level of profit earned by a direct problem of maximization which is formed from the same data. But this is exactly what is wanted. The new direct problem is formed from the same data as shown in Table 3 when both M_1 and M_2 capacities are raised to 15 hours. Hence the dual theorem predicts that a $1.00 increment in total return will be experienced if the indicated alteration is employed to best advantage. This is readily confirmed in this case since

$$\text{Maximize } \$1.00\ x_1 + \$\tfrac{1}{2}\ x_2$$

subject to:

$$\begin{aligned} 3\ x_1 + 2\ x_2 &\leq 15 \\ 5\ x &\leq 15 \end{aligned} \qquad (10)$$

has the solution $x_1 = 3$, $x_2 = 3$. Substituting these values in the linear form of (10) yields, as predicted, $1.00 (3) + $½ (3) = $4.50.

The values $w_1 = \$.25$ and $w_2 = \$.05$ obtained from (9) are therefore the required evaluators for the proposed facilities alterations. Each hour's increase in M_1 capacity will increase total profit by $.25 and each hour's increase in M_2 capacity will make possible a $.05 increase in total profit. The two values thus secured may be used jointly or separately as, for example, when the relative desirability of expanding one capacity or the other is at issue.

This theorem (and others as well) may be used to expand the scope of linear programming in ways which are not, perhaps, immediately obvious.† Indeed there are other uses of this duality relation which are even more important when viewed from the standpoint of future progress in management science and operations research. For example, the dual theorem provides a bridge between linear programming and another important OR tool known as the theory of games. This discipline is again relatively new, having been originated by John von Neumann and, in collaboration with Oscar Morgenstern, published in book form (7) as recently as 1944. It provides an important advance over the classical notions of probability theory by admitting deliberate strategies as well as pure chance. Professor A. Wald, who founded the modern field of statistical decision theory (8) and thus provided another important tool for the OR kit, was also able to provide a means of relating his findings to the theory of games.

* These values will change at certain levels which can be isolated in advance by the methods of linear programming. These kinds of programming studies in OR applications are called sensitivity analyses.

† As noted above, these questions are answered without additional effort, as a by-product of standard linear programming calculations. See (*5*).

OPERATIONS RESEARCH

It is clear that all three of these disciplines bear important relations to each other so that flexibility and power is added to each. Ackoff (*1*) has indicated that OR is characterized by the nature and the power of the scientific tools which it is able to bring to bear on management problems. The foregoing examination suggests that there is an underlying unity among these tools so that OR has more structure and, hence, more discipline to it than is apparent on a superficial examination. The breadth and promise of this area of work cannot be accurately gauged at present. Related areas such as electronic computers, information theory, and statistical analysis must also be considered. All are relevant to the scientific study of management problems—i.e., operations research and management science. There is some evidence of an underlying unity to these developments. Indeed, all seem to be part of the rapid evolution of means for extending the sphere of science from the confines of the classical laboratory approach to the multiple variable considerations which are so apparent in management and other "uncontrolled" situations.

Table 3

Mathematics		Management
maximize $1 $x_1 + \$\frac{1}{2}x_2$	Linear form to be optimized	Criterion of accomplishment and statement of objective.
subject to:		
$3\ x_1 + 2\ x_2 \leq 12$ $5\ x_1 \leq 10$ $x_1, x_2 \geq 0$	Constraints to be met	Plant and product conditions.
$x_1 = 2,\ x_2 = 3$	Solution	Best program returns $3.50.

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the mechanism of
HOT-SURFACE DRYING OF FIBROUS SHEETS

*Arthur C. Dreshfield, Jr.** | The Institute of Paper Chemistry, Appleton, Wisconsin

Measurement of the moisture content of fibrous sheets by beta-ray transmission (plus use of dyes to determine the migration of liquid within the sheet and location of zones of vaporization) was the basis of this study. Results may not only aid in understanding the mass transfer mechanisms of rapid hot-surface drying, but may also suggest other applications for the new experimental method developed and employed.

The drying of a sheet of fibrous material, such as paper or textile fabric, on a hot surface is a common industrial operation. In this operation, one side of the sheet material is in contact with a hot surface, from which the heat required for vaporization is transferred by conduction. The water vapor is removed from the open surface of the material by a stream of air. The mechanism of the simultaneous heat and mass transfer involved in such a drying operation is not yet fully understood. Knowledge is inadequate concerning the gradients and the movements of liquid water within the sheet, the location of the zones in which vaporization occurs, and the movement of water vapor out of the sheet. To obtain such data, a new technique has been developed continuously for determining the moisture content of a wet sheet without disrupting the drying process.

Experimental Techniques

Two specific techniques were employed in this study: one designed to measure the moisture content either of an entire sheet or of any transverse fraction of a sheet, and the other intended to trace the movement of liquid within the sheet and to locate the zones of vaporization.

Hot-surface drying of paper proceeds too rapidly to permit the use of the conventional technique for determining moisture distribution, which is, to interrupt the drying of a specially prepared sheet, separate the sheet into laminates, and determine the moisture content of each laminate. To overcome such difficulties, a new technique for moisture-gradient determination was developed. This technique is based on the relationship between beta-ray transmission and the specific mass of matter, specific mass being defined in this study as the mass per unit area. The beta-ray transmission of water is measured continuously during drying. The quantitative relationship between the beta-ray transmission of water and its specific mass is established for the particular system and conditions by an empirical calibration procedure.

For over-all drying studies, a source of beta radiation is placed on one side and a radiation detector on the opposite side of a sheet of paper, and the beta-ray transmission of the sheet is measured and recorded continuously during drying. The recorded data are transformed to the moisture content of the sheet as a function of the drying time by the use of the empirically established calibration.

To determine the moisture content of that portion of a sheet between the surface facing the radiation detector and any desired plane within the sheet, the source of radiation is deposited at the desired plane. In this case, changes in radiation backscattered to the detector from the rest of the system must be small compared with changes in transmission of the portion under study. By drying under similar conditions a set of sheets, which are identical except for the location of the radioactive plane, drying curves for several fractional portions of the sheet are determined. By cross-plotting such data in a manner described later, moisture gradients during drying can be calculated.

To follow the movement of liquid water and to locate the zones of evaporation, a soluble, nonsubstantive, nonvolatile dye is dispersed in a sheet made up of two or more laminates wet-pressed together. In an experimental run, drying is interrupted at the desired time, the sheet is delaminated, and the amount of dye in each laminate is determined.

Results and Discussion

ACCURACY OF RESULTS

An inherent limitation of the accuracy of the method for determining moisture content lies in the nature of beta-radiation emission. Although the average emission rate of beta radiation in relation to time is strictly first order and may be characterized precisely by the half life of the isotope, the rate at any instant is subject to fluctuations about the mean value because it is the sum of a finite number of random individual events. As the number of events counted becomes large, the distribution of measured emission rate approaches the Poisson distribution (*2*), in which the standard deviation of the emission rate is equal to the square root of the emission rate. In this work, the time interval for 10,000 counts constitutes one datum point. The standard deviation of a single point, therefore, is equal to 100 counts, or one per cent. Referring to Figure 1, the change of specific mass of water

* Mr. Dreshfield is at present with Scott Paper Company, Chester, Pennsylvania.

corresponding to a one per cent change in transmission varied from 0.32 mg./sq.cm. at a specific mass of 60 mg./sq.cm. to 0.48 mg./sq.cm. at zero specific mass. These values may be considered as a conservative estimate of the accuracy of moisture content.

An experimental check of the accuracy of the sheet preparation work was obtained by calculating the beta-ray transmission from the counting rate for the sheet at the start of a drying run, at the end of a drying run, and for the source of radiation in the absence of a sheet. The intended initial specific mass of water in the sheet and the specific mass of the dry sheet were known. If all the procedures were exact and precise, each datum point so calculated should fall on an appropriate curve of Figure 1.

The actual data obtained in this manner are shown as the triangular points. It is seen that the agreement for the dry sheets was good, the maximum observed deviation among 11 sheets being less than ± 1 mg./sq.cm. from the prescribed value of 28.2 mg./sq.cm., and even less for lighter sheets. The accuracy of the calculated initial moisture content was not as good. The maximum deviation observed was 4.5 mg./sq.cm. and the average deviation was about one third of this. The discrepancy may be explained by the fact that the sheets were brought to a known initial total weight so that any variations in the mass or in the area of the dry sheets would be reflected in the initial specific mass of water. Variations in moisture loss between the time the sheets were weighed and the time the scaler was started would also be reflected as scatter in the initial moisture content of the sheets.

Examination of Figure 2 shows that drying rates can be closely reproduced. Replicate constant-rate drying rates for all sheets of a given mass agreed within 2 per cent. Evidently, the various procedures used in the preparation of sheets did not affect the drying rate to a measurable extent. Furthermore, adequate reproducibility of the condition between the sheet and the hot surface was attained.

The limitations of accuracy inherent in the transmission data and some minor differences between the sheets of a series cause some scatter in the moisture gradient data. This scatter becomes relatively more serious at low moisture content, as is evident from Figure 3. A number of slightly different curves could be fitted to the data, each of which would give a modified moisture gradient. It is estimated that discrepancies as great as 10 to 15 per cent are possible at some internal points. Consequently, the moisture gradients at very low moisture contents are unreliable.

OVER-ALL DRYING RATES

Drying of all sheets exhibited the normal behavior of a constant-rate period followed by a falling-rate period. Table 1 is a summary of data for over-all drying rates.

The hot-surface temperature shown in the table was not measured directly, but was calculated from the circulant temperature, the appropriate heat transfer coefficient, and the quantity of heat transferred at the constant rate. When water was the circulant, the temperature drop from the fluid to the hot surface was always less than 2° F. In the case of glycol, the temperature drop amounted to as much as 13 ± 2° F. The critical moisture content was obtained as the point at which the drying curve deviated measurably from the constant-rate line. Since the change in drying rate at that point was small, the critical moisture content could not be determined with great accuracy.

The drying rate in the constant-rate period was a strong function of both the hot-surface temperature and the

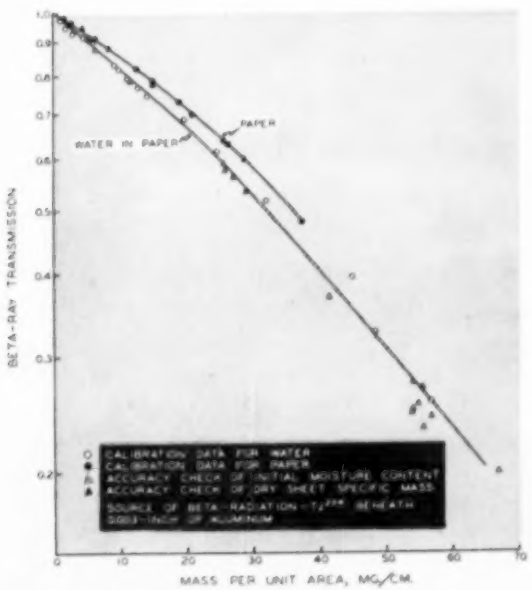

BETA-RAY TRANSMISSION
MASS PER UNIT AREA, MG./C.M.
WATER IN PAPER
PAPER
CALIBRATION DATA FOR WATER
CALIBRATION DATA FOR PAPER
ACCURACY CHECK OF INITIAL MOISTURE CONTENT
ACCURACY CHECK OF DRY SHEET SPECIFIC MASS
SOURCE OF BETA-RADIATION - Tl204 BENEATH .0003-INCH OF ALUMINUM

Fig. 1. Beta-ray transmission of paper and water.

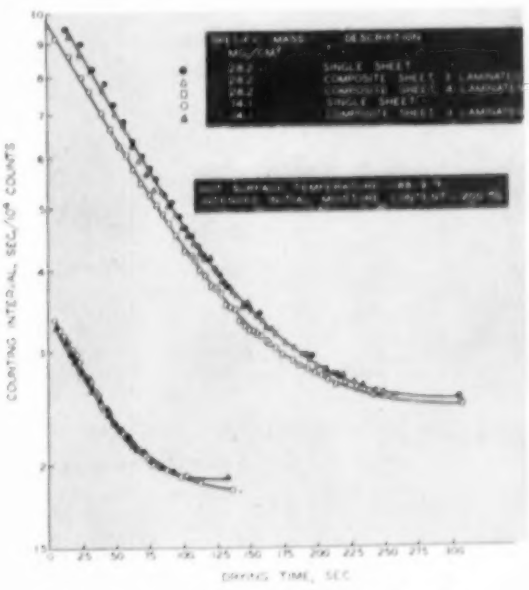


Fig. 2. Typical beta-ray transmission data during drying.

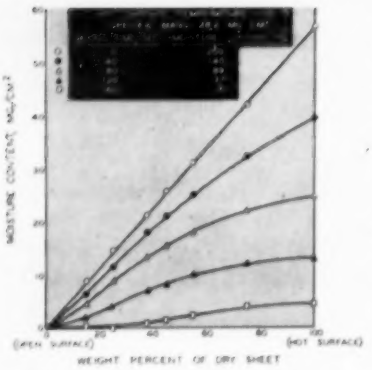


Fig. 3. Moisture content during drying.

specific mass of the dry sheet but was independent of the initial moisture content. The constant rate approximately doubled for a temperature change from 169 to 221° F. An increase in the specific mass from 3.5 to 28.2 mg./sq.cm. halves the drying rate at 189° F. The conditions of the air stream did not exert a great effect on the drying rate. The critical moisture content depended slightly on the initial moisture content and increased with increasing hot-surface temperature as well as with specific mass. These findings are substantially in agreement with those of McCready (*3*), who dried thick laps of pulp under experimental conditions similar to those used in this work.

CHARACTERISTICS OF MOISTURE GRADIENTS

The moisture gradients found in a typical set of sheets are shown in Figure 4. Starting at the open surface of a sheet, the moisture content at planes within the sheet increased with sheet fractional weight until a zone at about 20 to 30 per cent of the sheet was reached. Somewhere within this zone, the moisture content was a maximum. From this zone to the hot surface, the moisture content decreased continuously, and the dryest section of the sheet was closest to the hot surface. As the drying proceeded, the moisture content in all portions of a sheet decreased. The zone of maximum moisture content persisted as far into the falling-rate period as could be followed experimentally.

Moisture gradients were also determined in a series of sheets having the same specific mass but dried at a lower temperature and in another series having lower specific mass but dried at nearly the same temperature as the series just discussed. The nature of the distribution found in both of these series was similar to that shown. However, the gradients were less pronounced than the corresponding gradients shown in Figure 4. Within experimental accuracy, the zone of maximum moisture content was located in the same weight fraction of all the sheets.

The moisture distribution reported by McCready (*3*) was based on the moisture contents determined from three laminates of a composite sheet. These were 128, 128, and 37 per cent moisture in the successive laminates from the open surface. The fact that McCready did not find an internal maximum moisture content can be attributed to this experimental technique. With reference to Figure 3 or 4, if the sheets had been separated into three equal portions after 80 seconds of drying, the moisture content in successive laminates from the open surface would have been 124, 98, and 43 per cent, and the zone of maximum moisture content would not have been detected. On this basis, the similarity in moisture distribution between these sheets and the one reported by McCready becomes evident. Comparison of these data with the capillary equilibrium data for pulp of Barkas and Hallan (*1*) indicates that capillary equilibrium did not exist during drying.

DYE DISTRIBUTION AND MOVEMENT

Some dye migration during handling is unavoidable. To determine the magnitude of this migration, a preliminary experiment was performed with a sheet of uniform initial dye distribution. The sheet was dried for one second at 190° F. The dye distribution found after delamination is shown in Table 2.

Because appreciable dye migration occurred during handling, the data obtained for wet sheets by this dye technique cannot be used as a quantitative measure of liquid water movement during drying. For sheets which were completely dried before delamination, dye migration during handling was undoubtedly negligible. However, Preston and Chen (*5*) have indicated that the correspondence of dye movement to liquid water movement may be poorer at low sheet moisture content. Because of these factors, the results of dye distribution are only indicative of the general direction and magnitude of liquid movement.

Figure 5 shows the distribution of dye in the sheets of 28.2 mg./sq.cm. dried from 200 per cent initial moisture at a hot-surface temperature of 221° F. At any moisture content, the distance between two neighboring curves represents the amount of dye found in the specific portion of the sheet. Movement of dye toward the surfaces started very early during drying and continued at least part way into the falling-rate period. In all sheets, a very marked concentration of dye at both surfaces was observed.

Table 1.—Summarized Over-All Drying Data

Hot-surface temp., ° F.	Dry sheet wt. mg./sq.cm.	Initial * moisture content, % (dry basis)	Air velocity, ft./min.	Air dry-bulb temp., ° F.	Air wet-bulb temp., ° F.	Constant-rate drying rate mg./sq.cm. (sec.)	Critical moisture content, % (dry basis)
168	3.5	200	250	95	79	0.40	40
169	28.2	200	250	95	79	0.214	60
183	28.2	200	250	85	70	0.256	50
183	28.2	200	250	95	79	0.256	50
183	28.2	200	435	85	70	0.260	50
188	14.1	210	250	95	79	0.395	55
188	7.0	175	250	95	79	0.41	25
188	3.5	115	250	95	79	0.45	35
189	28.2	235	250	95	79	0.296	55
189	28.2	200	250	95	79	0.299	50
189	28.2	155	250	95	79	0.302	40
202	28.2	195	250	95	79	0.355	70
217	7.0	145	250	95	79	0.68	30
219	14.1	185	250	95	79	0.58	55
221	28.2	195	250	95	79	0.45	95

* Extrapolated values.

Table 2.—Dye Migration During Sheet Manipulation

Laminate position	Open surface		Hot surface	
Laminate weight, % of total sheet	15	35	35	15
Dye in laminate, % of total dye	19	30	33	18

An equally important finding is the existence of a zone of minimum dye content within all sheets at all times during drying. The portion 15-50 per cent from the open surface contained less dye at all times than did an equal but adjacent portion of the sheet. It was further found that the specific mass of the dry sheet and the temperature of the hot surface exerted no appreciable effect on the final dye distribution. The amount of dye migrating from the interior to each surface definitely decreased as the initial moisture content was decreased.

To determine the direction of liquid water movement from various internal planes, a series of qualitative experiments was carried out. A stack of filter papers was formed in which every sheet contained the same amount of water, but only one sheet contained dye. The stack was held on a heated drum by a spring-loaded wire screen. After the stack had dried, individual sheets were examined for dye content. Excluding the edges of the sheets, it was observed that dye initially in the upper 20 per cent of a stack was concentrated at the upper or open surface. Dye initially in the lower 60 per cent of a stack was found to be concentrated at the lower or hot surface. Dye initially in the intermediate region moved partly to the hot surface and partly to the open surface. Comparison of these findings with the previous moisture gradient data indicates that the liquid water always moves in the direction of decreasing moisture content.

Mechanism of Hot-Surface Drying

The results obtained in this work have indicated that the same basic behavior prevailed throughout the range of conditions studied. There was no sharp change in mechanism at the critical moisture content. Comparison of these results with the findings of McCready (*3*) for heavier sheets dried under similar conditions also suggests that the drying mechanism of a light and a heavy sheet is similar.

The general conditions existing within a sheet during the constant-rate period and the first part of the falling-rate period are depicted in Figure 6. To summarize the experimental facts again, the maximum moisture content was located in a zone from 20 to 30 per cent of the distance from the open to the hot surface. In this same region, a zone of minimum dye content existed. There appeared to be no movement of dye, and therefore no movement of liquid water across this zone. Liquid water which was initially between this zone and the hot surface moved toward the hot surface; liquid water which was between this zone and the cold surface moved toward the cold surface. The movement of liquid water was in the direction of a decreasing moisture content and was predominantly toward the hot surface of the sheet.

Water vapor can leave the sheet only at the open surface. Therefore, the liquid water moving to the hot surface must have been vaporized there, and the resulting vapor must have moved back through the sheet in order to escape from the open surface. The concentration of dye found at the closed surface indicates that most of the vaporization occurred there.

A significant amount of vaporization also occurred at the open surface, as indicated by the dye concentration. Calculations have shown that the temperature at this surface was higher than that of the air; consequently sensible heat was transferred from the sheet to the air. The heat required for vaporization at the open surface as well as the sensible heat transferred to the air must have been propagated through the sheet from the hot surface by conduction.

Without the support of the present experimental evidence, four possible cases accounting for the mechanism of hot-surface drying may be suggested. In terms of the water and dye distribution, the various possibilities are represented in Figure 7. These diagrams serve merely as illustrations. The dye content, relative to the water content, is greatly exaggerated. The basis of comparison is the same uniform initial water and dye content in each. It is understood that water exists predominantly in the liquid form, the weight of water vapor present within a sheet being negligible. The movement of water is assumed to correspond to that of dye. Relative to adjacent zones, a local increase in the dye content with respect to water (that is, dye concentration) indicates either net vaporization at the zone of increase or net condensation in adjacent zones.

If the only phenomena involved in hot-surface drying were liquid migration to the surfaces of the sheet and vaporization at the surfaces, the distributions shown in Case 1 of Figure 7 should have been found. The dye concentration in liquid water would have been constant throughout the sheet (except at the surfaces), or might even have increased slightly in the center of the sheet, since dye migration may lag slightly behind liquid water movement. As shown, the sheet would have had a maximum dye content in the same region as the maximum water content.

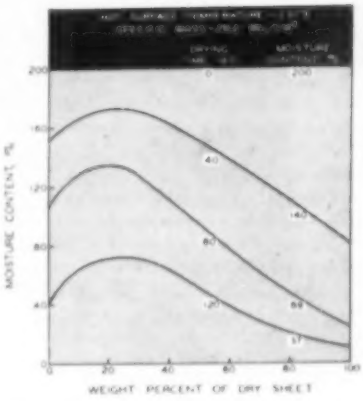


Fig. 4. Moisture distribution during drying.

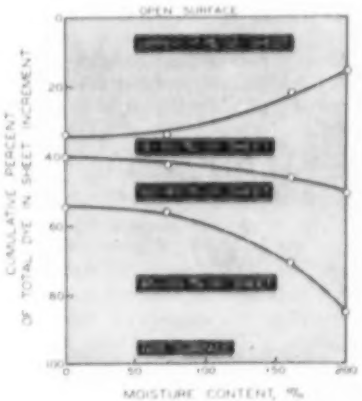


Fig. 5. Dye distribution during drying.

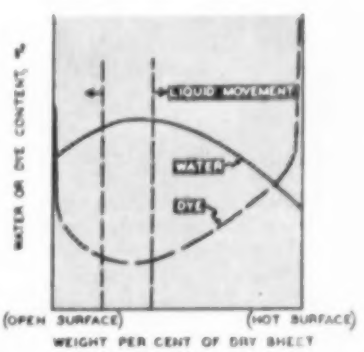


Fig. 6. Typical distribution and movement of water and dye.

Case 2 of Figure 7 indicates the possibility that an external pressure gradient caused by heating of vapor at the hot surface caused liquid movement, a mechanism postulated by Nissan (4). Liquid water would have moved from the hot to the cold surface under the influence of an over-all pressure gradient and would have vaporized at the cold surface. The dye content of the sheet would have corresponded to the moisture content, so that there would have been a minimum in the dye content of the sheet at the hot surface.

Case 3 of Figure 7 shows one possible type of internal vaporization. It is assumed for this case that the relative extent of vaporization is greatest at the surfaces and becomes continuously less toward some region in which the rate of vaporization is a minimum; it is further assumed that liquid water moves in the direction of decreasing moisture content. A zone of maximum moisture content would be observed and the dye concentration would increase steadily from this zone toward each surface since net vaporization is occurring relative to that in the zone of maximum moisture. However, if this mechanism existed, the absolute dye concentration would increase with time, and there would not be a sharp concentration of dye at the surfaces of the sheet. Instead, a dye gradient which increased smoothly right up to and including the surfaces would be expected.

The actual distribution found corresponds to Case 4 of Figure 7. Dye was concentrated at the surfaces of the sheet; this indicated that liquid water had moved to and evaporated from these regions. Within the sheet, the dye concentration in liquid water decreased continuously from just below each surface to the region of maximum moisture content, which was also the region of minimum dye content. In this region, the dye concentration decreased relative to the initial value. Since vaporization was occurring at the surfaces only, this indicates that the liquid water (containing dye) originally present in the sheet must have been diluted with water that did not contain dye. Such water could only be condensate from vapor which had been formed elsewhere.

It has already been noted that the vapor formed at the hot surface must pass through the sheet and escape into the air at the open surface, and that the partial pressure of vapor formed at the hot surface is greater than the saturation pressure in the rest of the sheet. Calculations by McCready indicated that the vapor leaving the open surface was most probably in equilibrium with water at that surface. If vapor within the sheet was also at or near saturation, there must have been condensation-vaporization within the interior of the sheet. The observed dilution of dye indicates that net condensation occurred in these cycles. Heat liberated by such cycles was propagated to the open surface by conduction. This heat caused net vaporization at the open surface, the only place at which subsequent condensation would not occur.

Conclusion

It is now possible to present a fairly complete description of the mechanism and phenomena of hot-surface drying. At the start of drying, there is a short period in which the drying rate and temperature distribution adjust from the initial conditions to the stable characteristics of constant-rate drying. During the constant-rate period, heat is being added to the sheet at the hot surface, and vaporization of water occurs there. This vapor has a partial pressure greater than the equilibrium vapor pressure for the rest of the sheet. Internal condensation takes place as the vapor passes back through the sheet and enters the air stream from the open surface. The heat transferred to the sheet by the condensing vapor is moved by conduction in the direction of decreasing temperature. At the open surface, a small fraction of the heat is transferred to the air by convection, and the remainder causes net vaporization.

The vaporization at the two surfaces depletes the liquid water content of the sheet in these regions. The process proceeds too rapidly for capillary equilibrium to be maintained, and moisture gradients are thereby established; this causes the movement of liquid water toward the surfaces. The rate of drying is determined by a complex balance of heat and mass transfer, the terms of which cannot be determined at present.

This process continues until the zone at the hot surface becomes too dry to maintain a steady rate of vaporization at the hot-surface interface. At this time, the temperature drop across this zone increases and the rate of heat transfer to the sheet decreases. Under such a condition, a sequence of events takes place. The temperatures of the rest of the sheet decrease, the vapor pressure of water at the open surface diminishes, and the drying rate decreases accordingly. The critical moisture content is thus related primarily to the moisture content at the hot surface. For a given moisture content at the hot surface, the average moisture content of a sheet is greater as the moisture gradient becomes greater. Any change which enhances the moisture gradients, such as an increase in specific mass or in hot-surface temperature, causes an increase in the critical moisture content.

Below the critical moisture content, the zone in which vaporization occurs moves slowly away from the hot surface, and a continuous readjustment of temperature within the sheet occurs. Liquid migration continues in the falling-rate period, probably until the front of the zone of vaporization has reached the zone of maximum moisture content. By this time, the moisture content of the sheet is very low. There is no longer any continuous liquid water network, and the remaining water is removed by vaporization *in situ* and the diffusion of water vapor from the interior.

Apparatus

The apparatus consists of a hot-surface unit placed in an insulated duct through which conditioned air is passed. The hot surface unit, as shown in Figure 8, is located on the floor of the duct with the face up. The surface has a radius of curvature of 2.5 ft. and a usable area 4-in. square. It is made from an aluminum plate mounted on a hollow brass body. Aluminum was chosen for its backscatter characteristics. The sheet is secured against the hot surface by the clamping device shown in the figure.

Heat for drying is supplied by circulating a fluid through the hot-surface unit from a thermostatically controlled tank. Water is normally used for temperatures up to 200° F., and ethylene glycol for higher temperatures. Air, heated electrically and humidified with injected steam, is supplied to the duct by a blower. The air flow rate is controlled by the speed of the blower and by a damper, and is measured by means of a calibrated flow nozzle. The dry-bulb and wet-bulb temperatures of the air stream are measured by two mercury thermometers located between the flow nozzle and the hot-surface unit. Figure 9 is a schematic diagram of the apparatus for measuring and recording the rate of beta radiation.

OPERATION

The operation of the unit is as follows: the timer starts when the scaler is started. When 10,000 counts have been received, the scaler resets to zero and momentarily closes the relay. One set of contacts of the relay fires the Strobotac which illuminates the clock face. Since the camera contains no shutter, the result is a picture of the clock dial showing the timer reading when 10,000 counts are reached. The other set of contacts closes power relay *H*, which energizes solenoid

K to advance the camera one frame, making it ready for the next picture. The mechanical delay of the solenoid assures that the picture will be taken before the film in the camera begins to move.

Data are thus obtained as a series of timer readings which represent the time elapsed since the start of scaling. The difference between successive readings is the time interval required for the reception of 10,000 counts by the scaler.

PREPARATION OF RADIOACTIVE SOURCE

The radioactive material used in this study was thallium 204, a pure beta-ray emitter having a half life of 2.4 years. The maximum energy of radiation is 0.78 million electron-volts.

For over-all drying runs, 20 microcuries of thallium was immobilized as sulfide on a thin sheet of aluminum foil. This foil was held firmly against the hot surface with the radioactive source facing the hot surface.

For the determination of moisture gradients, the thallium was deposited on a sheet of special paper by the following procedure: the thallium was absorbed on a cation-exchange resin which had previously been ground and fractionated to a size range less than 20 microns. These resin particles were dispersed in a resorcinol-formaldehyde liquid resin, and the dispersion was used to coat the special sheets which weighed 1.1 mg./sq. cm.

PREPARATION OF DRYING SAMPLE

All single sheets were formed in a sheet mold from lightly beaten bleached sulfite pulp by a procedure similar to that specified in TAPPI Standard Method T-205m-53 (6). For an over-all drying run, a single sheet was used. Before the sheet was removed from the mold, a clean 0.0015-in. aluminum foil was pressed onto it. A sample of 2.55 by 3.62 in. was cut from the sheet. The sample was air-dried to slightly less than the desired wet weight and subsequently sprayed with a small amount of dextrinized starch solution. The starch served to prevent cockling of the sheet during drying. The sprayed sheet was sealed in a polyethylene bag and stored overnight to assure uniform initial moisture.

For moisture-gradient studies, three single sheets were laminated by wet-pressing to form a composite sheet. An aluminum foil was pressed to the sheet which was to be the bottom laminate. The intermediate laminate was a radioactive sheet previously described. Another single sheet served as the top laminate. A sample cut from the composite sheet was air-dried, sprayed with starch solution, sealed in a polyethylene bag, and stored overnight. A little soluble dye (tartrazine) was also included in the spray solution. Were any air bubbles entrapped or should any delamination occur, a spot of dye would be found at the point of defect. Data from any defective sheets were discarded.

Sheets for the study of water movement were assembled by wet-pressing

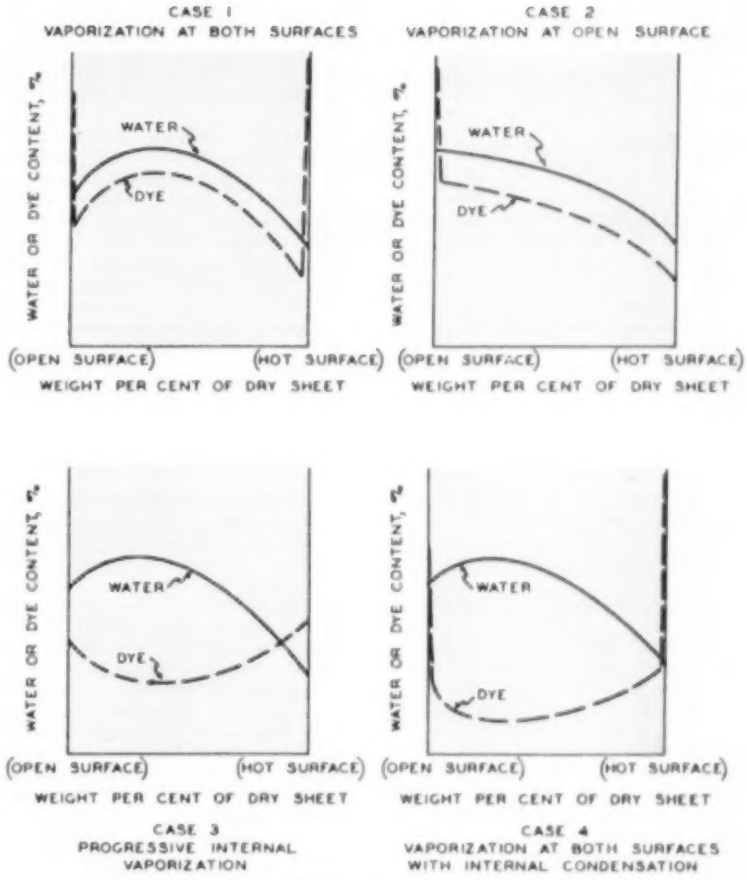


Fig. 7. Water and dye distribution for various mechanisms of drying

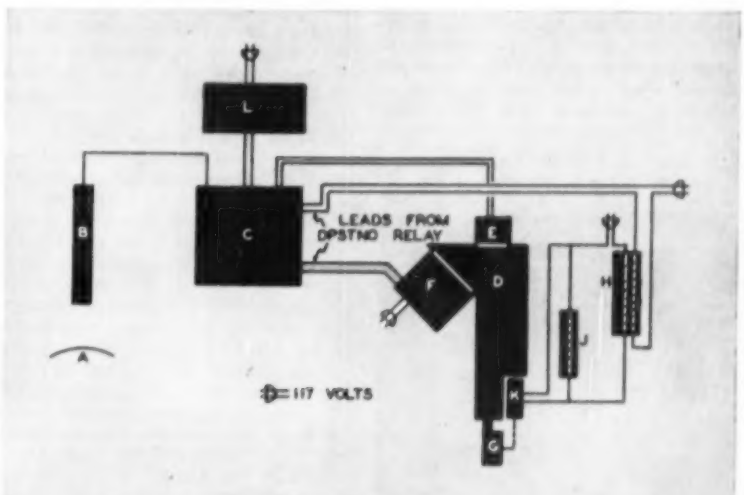


Fig. 9. Schematic diagram of apparatus for recording beta-ray transmission. A—source of radiation; B—scintillation head; C—electronic scaler; D—light-tight box; E—timer; F—Strobotac; G—camera; H—power relay; J—capacitative spark-quenching circuit; K—solenoid; L—voltage regulator; DPSTNO—double-pole, single-throw, normally open relay.

several laminates together. The bottom laminate was attached to an aluminum foil. Small tabs of paper were included between successive laminates at one edge in order to facilitate later delamination. Samples were prepared from the composite sheets in the manner just described, except that a more concentrated tartrazine solution was used and a period of 72 hours was allowed for equilibration of moisture and dye.

RUN PROCEDURE

A prepared sample was fastened securely on the hot-surface unit with the aluminum backing against the hot surface. For over-all drying or moisture-gradient studies, the scaler was started immediately, and the counting rate recorded until the sheet was dry.

For dye distribution studies, the sample was dried for a desired length of time, at the end of which it was immediately removed and delaminated. The dye in each laminate was extracted with distilled water and diluted to a known volume. The amount of dye in the solution from each laminate was determined by measuring with a spectrophotometer the optical transmittance of the solution, relative to distilled water, at the wavelength of minimum transmittance.

CALIBRATION OF BETA-RAY TRANSMISSION

The term "transmission" as used in this work is the ratio of the counting rate when the material is present to the counting rate when the material is absent. To obtain the relationship between the transmission of dry sheets and its specific mass, a series of sheets of different specific mass was made up. They were inserted one at a time between the source and the scintillation detector. For each sheet, the counting rates at the detector when the sheet was inserted and when the sheet was absent were determined. The specific mass of a dry sheet was determined by weighing the trimmed sheet and measuring its area.

The corresponding relationship for water was obtained from a series of wet sheets. These sheets were wrapped in 0.00035-in. aluminum foil to prevent evaporation during use. The beta-ray transmission of each wet, wrapped sheet was determined in the manner described above. The wet weight of each wrapped sheet was measured. After unwrapping and drying, the weights of the wrapper and of the dry sheets were obtained. The beta-ray transmission of each dry sheet was then determined. From these data, the beta-ray transmission and the specific mass of the water in each sheet were calculated.

The apparent beta-ray transmission for any material is dependent upon the specific mass of other materials present between the source and the detector. It was therefore necessary to correct the transmission obtained for water when the wrapping foil was present to the transmission which would be obtained without that foil. To do this, the transmission of a series of dry sheets was obtained with and without such foil, and these data were used to establish the relation between beta-ray transmission observed under the two conditions.

CALCULATION OF MOISTURE CONTENT

Figure 1 shows the beta-ray transmission of pulp and of water as a function of the specific mass of each. The circular points represent data obtained by the procedure just described. The triangular points derived from drying data are concerned with the accuracy of sheet preparation, and will be discussed subsequently. Within experimental accuracy, the transmission data for water in all sheets appear to be independent of the specific mass of the dry sheet in the range from 3.5 to 28.2 mg./sq.cm. This relationship is the one used to transform the transmission data of over-all drying runs into moisture content. A somewhat different relation would be obtained with a different experimental setup. In fact, for the sheets containing a source of radiation at an internal plane, another correlation (not presented in this paper) was used for moisture determination.

As explained previously, the raw data for a drying run are obtained as a series of photographs of a 1-sec. full-sweep clock taken at intervals of 10,000 counts. The difference in successive readings is calculated to the nearest 0.01 sec. The average elapsed time of the interval from the start of scaling is calculated to the nearest 0.5 sec.

These results are plotted on a semilogarithmic scale, examples of which are shown in Figure 6. In this figure the elapsed time is the abscissa, and the interval for 10,000 counts is the ordinate. The time lag of 1-2 sec. between the instant when the sheet contacts the hot surface and the instant when the scaler is started is neglected. Toward the end of a run,, when the counting rate is changing very slowly, the average of two or three successive intervals is plotted. A line of best fit is faired through the points for each run.

At selected times from the start of a run, the faired value of the interval for 10,000 counts is read from the graph. The constant counting interval obtained when the sheet is dry is divided by the interval at each of the selected times. The quotient is the percentage beta-ray transmission of the water in the sheet at that time. This value is converted to the corresponding moisture content in mass of water per unit area of sheet by the use of the appropriate graphical relationship, such as the curve for water in Figure 5. Over-all drying data, in the form of moisture content as a function of drying time, are used to calculate the initial moisture content, constant-rate drying rate, and critical moisture content.

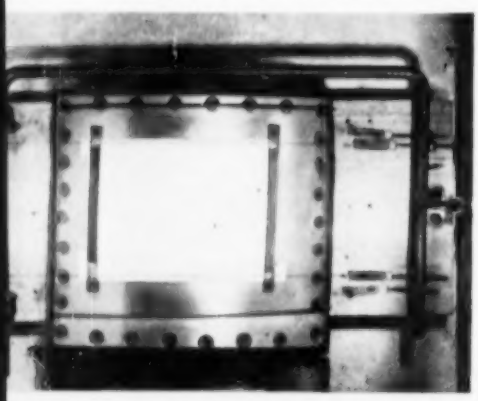
DERIVATION OF MOISTURE GRADIENTS

As mentioned before, for the determination of moisture gradients, a series of runs is necessary in which the radioactive source is located at various planes of similar sheets. For each sheet, the moisture content in a specific zone at all times during drying is obtained. From the data of the complete series, the moisture gradient at any time can be derived.

Individual sheets, however, varied somewhat in the initial moisture content. In order to reconstruct the moisture gradient, the calculated data from all individual sheets must be transformed to the same total moisture content. Since the drying rate is independent of the initial moisture content, as will be shown later, the loss of moisture for any duration of drying is the same for all sheets of one series dried under similar experimental conditions. Thus, the differences between the initial moisture content of a sheet and the average initial moisture content of all the sheets represent the necessary adjustment to bring all the sheets to the same total moisture content after any period of drying. This difference, the deviation from the average, is therefore added to the moisture content of each sheet found at all subsequent times.

A typical set of calculated data for one series of sheets is presented in Figure 3, in which the moisture content in the measured portion of each sheet is plotted against the size of the portion, expressed as weight per cent of that sheet. It is to be noted that 0 per cent represents the open surface and 100 per cent the hot surface. By taking the slopes of one curve at different points, the moisture gradients at any particular time are derived. The resulting moisture gradients thus obtained for the set of data shown in Figure 3 are presented in Figure 4.

Fig. 8. Top view of hot-surface unit.



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SAFETY ASPECTS of modern air separation plant cycles

P. G. Kerry | American Air Liquide, Inc., New York City, N. Y.

The conditions which have given rise to mishaps in air plants are of great interest to all who design, own, and operate these plants. Now that there have appeared in *CEP* (*1, 2*) two articles dealing with more or less specific approaches to the solution of the mishap problem, it now seems timely to correlate the various phases of the subject in a very general manner. This is particularly important so that those who are capable of contributing to the better understanding or to techniques aiding in the solutions of the technical problems involved, but who may not be directly connected with air separation plants in their modern form, may gain a better perspective of the problem.

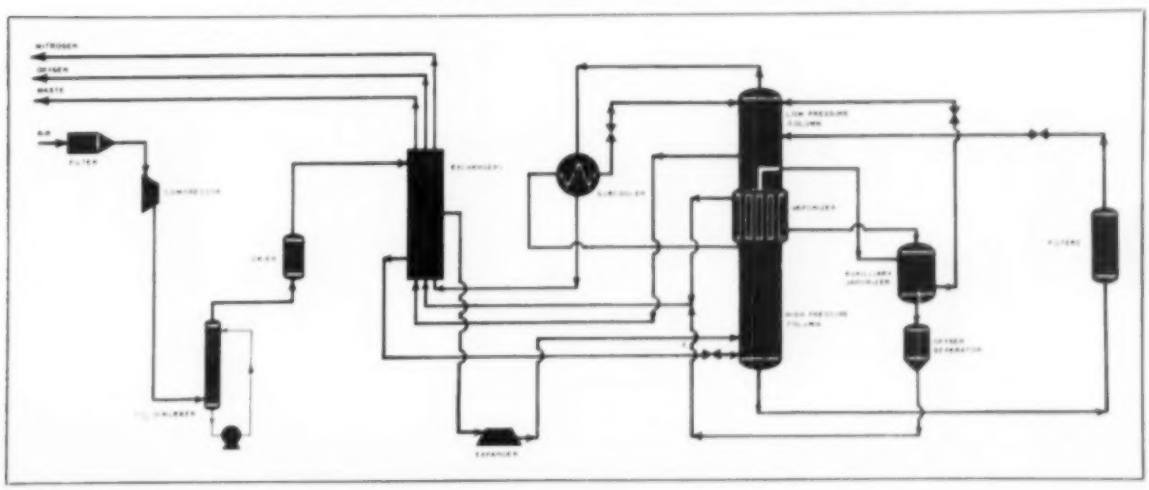
Standard Medium Pressure Cycle

First, consider the various cycles in use today. Figure 1 shows a standard medium pressure air separation plant using the best known classical cycle, one which has been used from the beginning of the industry. Briefly, its operation is as follows:

An air compressor supplies air at a pressure which may vary from 150 to 400 lb./sq. in. gauge; this compressed air passes through a standard caustic scrubbing unit which reduces the CO_2 content to 5 p.p.m. or less. The air then passes through a standard desiccation unit which reduces the water content to less than 1 p.p.m.; the purified air now enters the low temperature unit proper where it is first cooled down by heat exchange through standard shell and tube exchangers, liquefied, and finally separated into its components in a double fractionation column. The refrigeration is supplied by expanding a large portion of the air through either a reciprocating expansion engine or expansion turbine.

The above-described air separation unit is the most popular and the most extensively used air plant in the world because it can be built in a wide range of capacities and can produce simultaneously oxygen, nitrogen, and argon with very high purities and very high recoveries. No other air separation cycle can match the performance of this plant for all-around product recovery, product purity, and economy. Unfortunately, experience has shown that the medium pressure air separation cycle is the most susceptible to mishaps. This may be explained by the simple fact that contaminants may find themselves in the main condenser or vaporizer where a large quantity of liquid oxygen vaporizes slowly at almost atmospheric pressure. Unless proper precautions are taken both in design and operation, the contaminants

Fig. 1. Schematic flow diagram of a standard medium pressure air separation plant.



may build up beyond their solubility limit and trouble will ensue.

To overcome the problem arising from slow evaporation at nearly atmospheric pressure, designers have offered various modifications of the basic design of the main vaporizer so that purging could be effected, and have even added a second or auxiliary vaporizer which handles liquid oxygen withdrawn from the bottom of the main vaporizer. However, the auxiliary vaporizer does not stop explosions, but merely confines them in a different location. There is also indicated how various designers looked into different designs of vaporizers in order to effect a better heat exchange and vaporization and at the same time reduce the risk of high contaminant concentrations.

Results of tests of solubility of acetylene in liquid oxygen, plotted with the data of Fedorova and carried out by our own Research Laboratory, are shown in Figure 2. These curves indicate quite conclusively that designers of air plants should not accept a solubility limit for acetylene in liquid oxygen greater than 5 cc. per liter at the temperature level of liquid oxygen (−183° C.). Furthermore, the maximum solubility of acetylene in liquid nitrogen is 2.28 cc. per liter at the temperature level of liquid nitrogen. In checking our figures with those indicated by Fedorova (*3*), it is clear that Fedorova is even a little more conservative. In other words, designers should not, under any circumstances, assume figures in excess of those indicated above.

It is possible to show in graph form (Figure 3) what happens to the effective capacity for acetylene removal by silica gel filters if the latter are contaminated by foreign matter. For example, let us assume that the acetylene content of the air is 2 p.p.m. and that the silica gel filters have been designed to remove 97.5 per cent of the total acetylene entering the air plant during a given period of time. If the silica gel filter is contaminated by other foreign matter or improperly regenerated, then the effective capacity of the filter is sharply reduced. For instance, if the filter's effective capacity for the removal of acetylene is reduced to, say, 50 per cent, then the acetylene content permissible in the air must be reduced to 0.1 of 1 p.p.m. The above-described conditions hold true for a plant without an auxiliary vaporizer.

So far, reference has been made to a standard medium pressure air separation unit which has the advantage of supplying high purity products combined with high recoveries. As already stated, this is the most popular plant used in the production of high purity oxygen and also in the production of high purity nitrogen for most ammonia plants. On the other hand, because oxygen is vaporized at an atmospheric level in a large vaporizer, this air separation cycle is susceptible to an accumulation of contaminants in the main vaporizer and may give rise to trouble unless operated properly. This condition has been explained in detail (*1*).

Standard Low Pressure Cycle

Another air separation cycle that is used extensively in the metallurgical and petrochemical industries is the standard low pressure plant (Figure 4) which operates at an air pressure of 70 or 80 lb./sq.in. gauge and wherein regenerators or cold accumulators replace the shell and tube heat exchangers. This air cycle has certain definite advantages. It uses oil-free air blowers; the regenerators reduce the air temperature to almost its dew point, which means that the regenerators not only freeze out water and carbon dioxide, but also freeze out a great portion of the dangerous contaminants. This air cycle also offers oxygen at a very low cost because of lower horsepower. The regenerators themselves may be packed with either aluminum or other material, or may take the form of extended-surface aluminum exchangers with reversing passages. While this low pressure cycle is, from a design standpoint, considerably safer than the standard medium pressure cycle, it has the disadvantage of not being able to produce any appreciable quantity of very pure nitrogen plus another disadvantage of delivering oxygen at atmospheric pressure, which means the use of oxygen compressors with their inherent problems.

High Pressure Cycle

A few years ago, another air plant cycle was developed to overcome some of the problems of oxygen compression and at the same time deliver sufficient quantities of high purity nitrogen for use in ammonia synthesis. This plant is commonly known as the high pressure plant (Figure 5) wherein the compressors deliver the air at approximately 600 lb./sq.in. gauge. An external purification system is used for complete removal of carbon dioxide and water; the purified air enters the low temperature separation unit which is identical to that of any other air plant. However, the excess refrigeration due to the higher than normal pressure of the incoming air permits the oxygen to be withdrawn as a liquid away from the air unit proper and vaporized as well as compressed in a high pressure liquid oxygen pump; the vaporized oxygen then re-

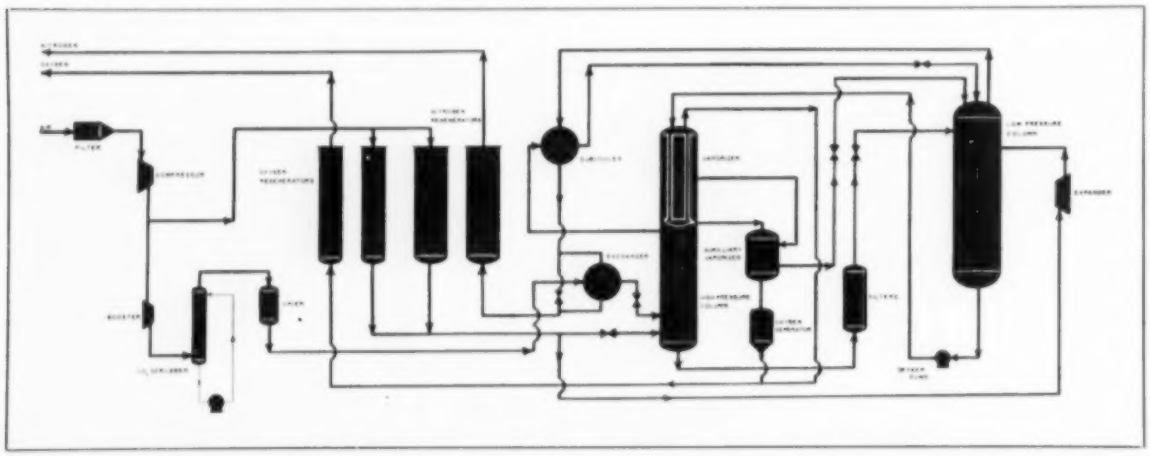


Fig. 4. Schematic flow diagram of a standard low pressure air separation plant.

enters the low temperature unit through a series of exchangers for cold recovery. This type of cycle has the advantage of using small inexpensive and trouble-free liquid oxygen pumps for oxygen compression and from a safety standpoint the oxygen is always withdrawn as a liquid from the main vaporizer which in reality acts only as a heat exchanger. On the other hand, the high pressure cycle has the disadvantage of requiring reciprocating compressors with their problems of lubrication and contamination and the other disadvantage of having a high horsepower consumption per ton of oxygen.

Double Cycle

More recently, in order to arrive at a compromise between a trouble-free plant and an efficient plant, a double cycle (Figure 6) unit has been built.

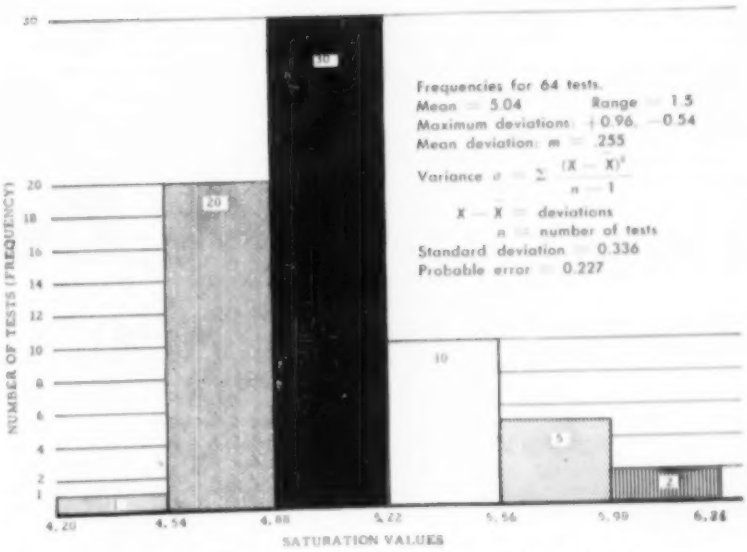


Fig. 7. Frequency distribution curve for solubility of various hydrocarbons in oxygen.

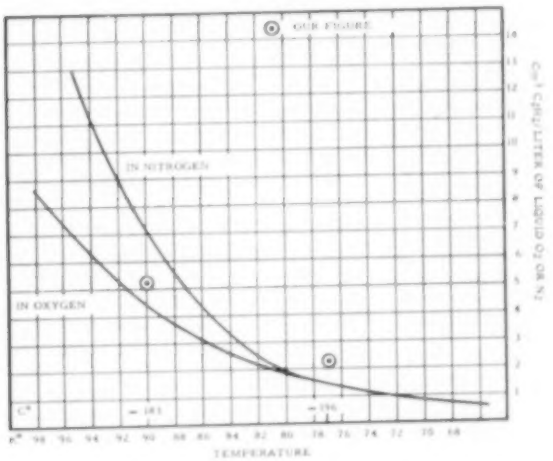


Fig. 2. Solubility of acetylene in liquid oxygen and nitrogen.

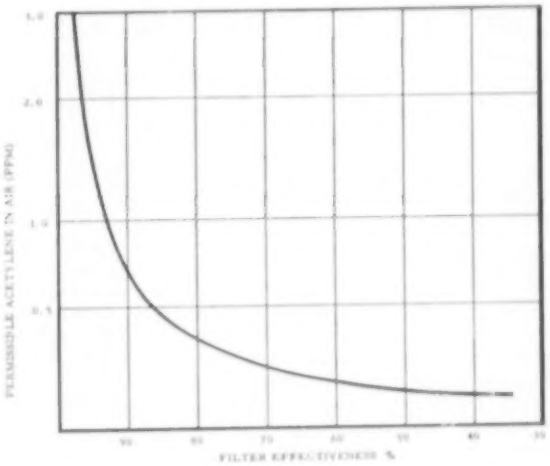


Fig. 3. Acetylene removal capacity of silica gel filters contaminated with foreign matter.

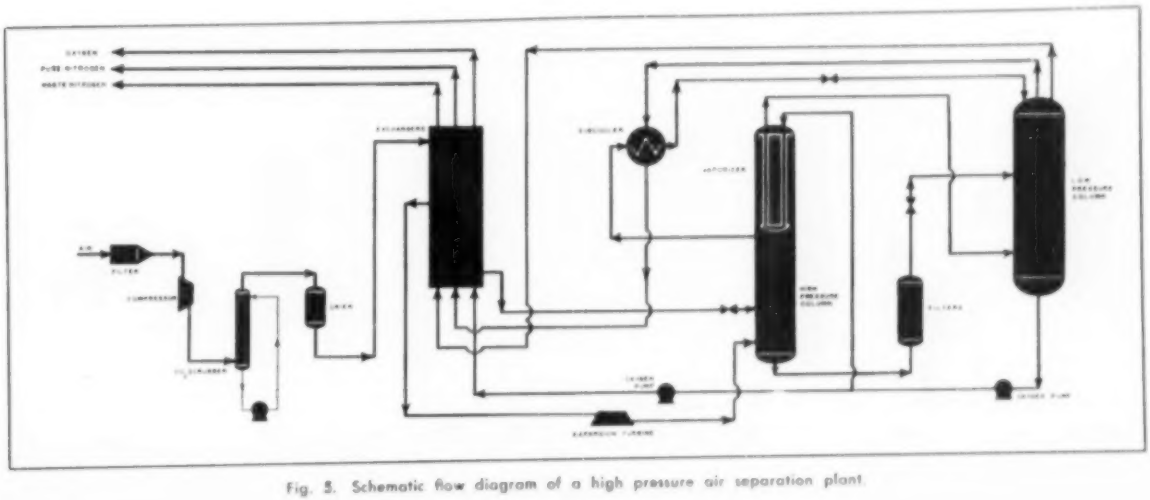


Fig. 5. Schematic flow diagram of a high pressure air separation plant.

All the air is compressed in an oil-free blower to 70 or 80 lb./sq.in. gauge. The greatest portion of the air enters standard regenerators or reversing extended surface exchangers which clean the air of contaminants as well as CO_2 and water. The balance of the air is boosted in an auxiliary compressor to a higher pressure; after pre-purification for CO_2 and water removal, the auxiliary air stream enters standard shell and tube heat exchangers. This double cycle air plant may be used in conjunction with liquid oxygen pumps for oxygen compression and at the same time produces an appreciable quantity of high purity nitrogen which can be used directly for ammonia synthesis. The advantages of this cycle are: a large portion of the air is comparatively free from contaminants; the oxygen is withdrawn as a liquid from the main vaporizer; oxygen compression is obtained from trouble-free liquid oxygen pumps. Concerning horsepower expenditure, the energy consumed by this cycle is only slightly higher than that consumed by a standard low pressure plant combined with gaseous oxygen compressors. Furthermore, even the other disadvantage of permitting the smaller portion of contaminated air to enter the unit may be offset by an inexpensive purification system in the auxiliary cycle.

Contaminants

Concerning contaminants, this discussion has so far been concentrated on acetylene, which is definitely known to be troublesome and with which we are familiar enough to offer some solutions. However, during the past few years, we have had definite case histories on plant mishaps wherein no acetylene was found either before or after the explosion. Furthermore, analyses carried out after some of the mishaps showed considerable traces of oxides of nitrogen and hydrocarbons other than acetylene. In other words, we cannot assume that acetylene is the only troublesome contaminant. We must investigate the roles of other contaminants and the conditions under which these contaminants will prove troublesome.

Just what final solution will render all air separation units absolutely trouble-free is still a question mark.

1. Very large silica gel filters can be designed, to be operated with daily switching. This may prove effective. However, it is still not absolutely foolproof and it is certainly not economical from an energy standpoint.

2. A liquid air reflux to scrub out incoming air before the latter enters the low temperature section proper may be used. This has been tried out; but it is not economical because it entails a relatively high purge loss. This system may be satisfactory in a plant producing high purity oxygen sold at so much per cubic foot, but it is not economical for a plant producing oxygen which must be assessed at the lowest possible cost per ton.

3. An air pre-filter system operating at low temperatures may be used. This system is effective, but has a relatively high investment cost and may not prove economical for plants producing over 100 tons per day of oxygen.

4. One may also consider the introduction of inhibitors. If certain substances have the capacity to lower the explosive limits of hydrocarbons, we may well introduce other substances which will serve as inhibitors. However, this idea, though reasonable, may prove questionable.

5. The best solution may ultimately prove to be the catalytic oxidation of the air prior to the latter's entry into the low temperature unit. However, this system requires more investigation regarding the type of catalyst, catalyst life, and overall costs.

What About the Future?

Concerning a future program or plan of action, the following recommendations are proposed:

1. A rapid and accurate method of analysis of air for:
   a. total hydrocarbons;
   b. concentration of individual contaminants.

2. A rapid and accurate method of analyzing for various contaminants within certain sections of the air separation unit.

3. A more accurate examination of the solubility limits of various hydrocarbons in liquid oxygen. (See frequency distribution curve, Figure 7.)

4. A more accurate determination of vapor pressure of various hydrocarbons.

5. A closer study of the reactions of hydrocarbons at low temperature levels to determine their explosive limits and conditions for explosions.

6. A more thorough study of various adsorbents for contaminant removal capacity and regeneration of adsorbing material.

7. A better design of air separation units to combine maximum safety with better economy.

The major designers of air separation plants already have research programs following in a general manner the above recommendations. To fulfill a program of this type, however, requires considerable time and money. To be of greater service to the industry, all design groups should sit together periodically to consider a joint program so that the above recommendations may be brought to a successful conclusion quickly, economically, and for the benefit of all. The results of such a program could easily be made available through the program and publications services of the A.I.Ch.E. So far as users are concerned, we ask only for their co-operation in supplying designers with field data from plant operations. This information is necessary and must be given freely if designers are expected to fulfill the requirements of safe design.

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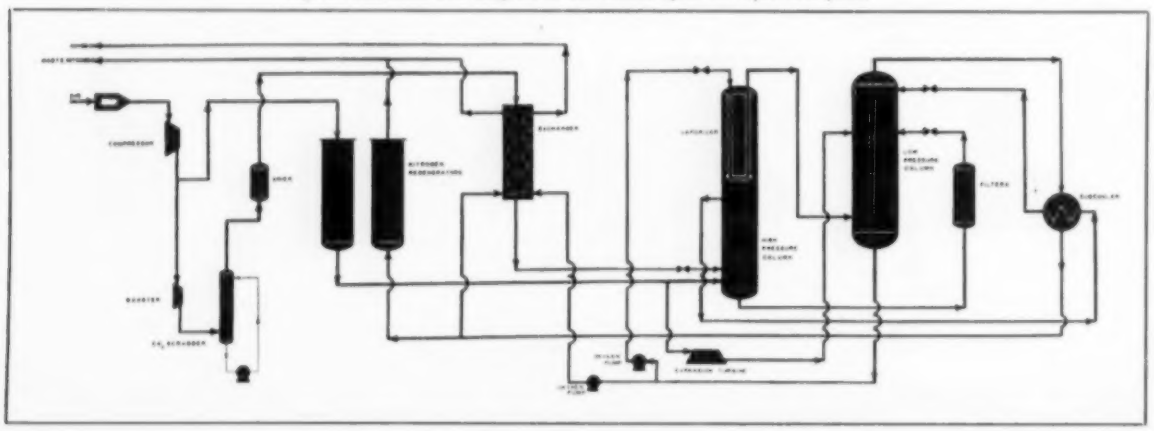
Fig. 6. Schematic flow diagram of the double cycle air separation plant.



what was said at A. I. Ch. E. OXYGEN PLANT SAFETY CONFERENCE

Earl C. Clark (Moderator): My job is Director of Operations of Air Reduction Sales Company. We operate 72 air separation plants throughout the United States and Cuba. We have a total of 126 producing units, many plants having multiple units. About 70 of these units were designed and built by Air Reduction and the others were bought from commercial suppliers such as Air Liquide, Messer, Air Products, and others. These 126 air separation units range in capacity from one ton per day up to 75 tons per day so we have a wide experience in operating all types of plants in a lot of different sizes. The main reason I am here today is that we have no plant equipment to sell. We sell only the products from air plants. Incidentally, we have never had an explosion in an oxygen reboiler in any of the units we have purchased. Now this brings us to the topic of this forum: the discussion of factors which contribute to the safety of air separation plants. Most of us have read Frank Kerry's paper (*CEP*, **52** No. 11, Nov. 1956, 441-7) which has provided the basis for this discussion session.

Latimer (Linde Air Products): I'm quite interested in the graph accompanying the Kerry paper, that shows the higher total hydrocarbon content of the air when the wind is blowing from the acetylene plant toward the oxygen plant in Montreal. Could Mr. Kerry tell us how much of that six to eight parts per million of total hydrocarbons is acetylene?

Kerry (Air Liquide): I'd say the amount of acetylene was slightly under five at maximum peak of the graph.

Latimer: In other words, the total hydrocarbons in that case are mostly acetylene.

Kerry: Mostly acetylene, that's right.

Latimer: I have one more question. We are quite interested in knowing what plant analytical methods you use for nitrogen oxides and ozone.

Kerry: We do have information on it—"Methods of Analysis of Impurities in Gases," available to Air Liquide clients.

Latimer: Are these primarily plant methods?

Kerry: That's right, they are not research methods.

In connection with the recent A.I.Ch.E. Annual Meeting in Boston, an informal discussion of oxygen plant safety was held as part of the regular program. Here is the transcript of the recording made of proceedings, in response to many requests. Readers may be interested in forthcoming symposia on oxygen and ammonia plant safety, to take place in connection with the Baltimore National Meeting in September, 1957.

A Consultant: On the general topic of explosions in air plants, where do they occur? Mr. Kerry has in his paper pointed to the area between the rich oxygen accumulation at the bottom of the high pressure column and the vaporizer after the low pressure column. That was probably true in the early plants which were located out by themselves, and acetylene was the main problem. But now, as he pointed out, there are other hydrocarbons, nitrogen oxides, and so forth causing explosions. I wonder if there is any comment on locations of the explosions physically in other parts of the low pressure plant besides the vaporizer?

Kerry: From our own company experience, we have never had any other significant explosions outside the main vaporizer. We have had reports of fires occurring in other areas, particularly in the filters. However, these were not due to any apparent fault in the filter itself. As we have read from the report (after the explosion) there was a sudden accumulation of oil vapor due to an upset in the mechanical end of the plant.

Consultant: Would it be possible to have some comments on the safety of operation of external horizontal type reboilers compared to internal or external vertical reboilers?

Moderator: I don't think we want to get into detail designs. Does Frank Kerry care to comment on this in a general way?

Kerry: I don't like to start describing the merits or demerits of various types of reboiler designs. Inherently, they're all good if they're properly operated, and that is the most important thing that users and future users should keep in mind. Oxygen plants are not simply a sideline utility in an over-all project, but are very important units in their own right which require good operating control. And one of the main operating controls is to make sure that the reboiler is functioning properly and the liquid is always at top level. In talking this matter over with our own Operating Department, its experience shows that whenever there has been a mishap, it was very often after a sudden plant shutdown followed by a restart and in the interim the vaporizer was allowed to go down in level. As a matter of fact, even during normal operation, if the liquid in the vaporizer were to go down beyond its level, trouble could occur.

Moderator: It has been my experience that when an explosion does occur it occurs in the lower part of the oxygen compartment in the reboiler. Some reboilers are more susceptible than others. We had a number of them in our company that were very

susceptible. We licked the problem by very carefully checking the acetylene concentration in the liquid every shift and maintaining a purge to keep the concentration down. Our experience has since been very good (over the past five years). We use acetylene as the tracer because we can easily and fairly accurately check the concentration of acetylene in the liquid oxygen. We feel that if the acetylene is present, other hydrocarbons are there too. If we can get rid of the acetylene, which we've always thought was probably the detonator, we've gotten rid of the other combustibles as well. We feel that if these plants are operated the way they were designed and intended to be operated, there should be no trouble.

Unidentified (General Chemical Division): I'd like to ask what method you use for analyzing such a small concentration of acetylene, either in liquid or gas phase?

Kerry: I think most plants use the Ilosvay solution method, which is a colorimetric method. You compare the color of the sample with those of predetermined standards.

Moderator: We also use a colorimetric method employing Ilosvay solution which analyzes down below 5 p.p.m. I wonder if any of you have any better method?

Kerry: We use infrared analyzers in our laboratories and we use them in large plants when we're starting up to check their performance, but we don't use them on a routine basis after we get down to normal operation. We want to know about acetylene in the area below 5 p.p.m. In fact we want to know when it gets between one to two.

Karwat: (At this point Dr. E. Karwat of Linde Company, Munich, Germany, read a comment which is the basis of a communication appearing separately in this issue of *C.E.P.*—see page 188.)

Julian Rogers (W. R. Grace): I'd like to comment on the use of synthetic lubricants. We are currently using a synthetic lubricant in the higher stages of the air compressors for our air plant. We do not have sufficient operating time to draw any definite conclusions. The experience to date, which has lasted for a few months, is excellent. We understand that the Ingersoll-Rand Company has surveyed synthetic lubricants and the results will probably be available to any one who is interested. We also understand that there are numerous operating companies using these synthetic lubricants in their compressors and getting very good success. I'd like also to add a few comments to the references Mr. Kerry has made regarding the operation of oxygen plants, that "you cannot design into them features to prevent their misoperation." That is true, but we should continue to strive toward this goal. There is one point that I feel has been somewhat overlooked in the discussion so far and this has to do with proposals to correct dangerous conditions. Many of the comments seem to be based on the assumption of a moderate or gradual influx of impurities into the system. From our experience we have found that in industrial plants there can be upsets in conditions entirely outside the air plant which will contaminate the atmosphere; and that the atmosphere, so contaminated, can change the hydrocarbon content of the liquid oxygen in the air plant within a matter of an hour or less by as much as one hundred fold. Fortunately, our case dealt with methane from natural gas, and our own experience, plus the literature, indicates that methane is not nearly as dangerous as acetylene or some of the other contaminants of air separation plants. The point I want to raise here is, wouldn't it be wise to channel some of our thinking toward safety measures to handle the *unexpected* in the plant by anticipation and prevention? In that regard, there has been quite a bit of work done on analyzers, particularly infrared. But considerable time lag is involved in these instruments and so far, much of the work has been done in analyzing liquid oxygen which only tells you (after the dangerous condition has occurred) that you have a time bomb sitting out there in the middle of the plant and you had better do something about it before it goes off. I might add that our immediate action was to relocate the air intake; however, this may not provide a complete or final solution.

McKinley (Air Products): I would like to comment just a bit upon the hydrocarbon impurity influx which can occur. I think that a constructive way of viewing the hydrocarbons that are, let's say, chemically unreactive, ones that will not form ozonides and peroxides, is to bear in mind at all times that they are fuels and can be made to explode with the oxygen provided they're concentrated. There is essentially no information in the literature concerning the explosibility of liquid mixtures of hydrocarbons and oxygen. There is, however, published explosion data for hydrocarbon gas-phase mixtures with oxygen. Since we are concerned with the lower explosibility limit, as a first approximation, either air or oxygen data may be considered as applying.

Experimentally, in dealing with the liquid oxygen system, the lower explosion limit may not appear just when we thought it should for the simple reason that it is a function of the method of initiation. If we put enough energy into that local volume or section associated with the hydrocarbon oxygen mixture, and if the molecules have in the liquid phase the same level of energy they would have if they were in the gas phase, then they should behave as if they were originally a gas mixture. In talking about methane, the lower limit is going to be something like five or more per cent. Now, dealing with the soluble hydrocarbons, these can exist up to their explosion limits in solution, and we can stand this situation as long as there aren't any side reactions. Many hydrocarbons, other than acetylene and methane, can come in with the air feed in some locations. Many of these will have solubility limits far lower than their explosion limits, so the explosion limit is not reached as a single phase mixture. But the explosion limit may be reached if conditions are such that there can be a local concentration. We have a two-phase mixture as a result of reaching the lower soluble limit and we have conditions set up for explosion. Mr. Clark pointed out that they keep the acetylene low. One of the reasons for this is simply to avoid reaching the solubility limit. We can view all the other hydrocarbons in the same light. Fortunately, most of the others have rather substantial solubility limits so they won't misbehave. We don't have to hold them to such low concentrations. On the other hand, there are several hydrocarbons that do have low solubilities. Methane is a rather universal atmospheric contaminant but has a high solubility limit—it is one that we can dispose of safely. In general, the solubilities of hydrocarbons in oxygen behave in this way: with the saturates or the higher the molecular weight, the higher the solubility; for a given number of carbon atoms in a molecule, the higher the unsaturation, the lower the solubility. As a first rule, if you have a higher molecular weight material, if it is highly unsaturated it is going to be quite insoluble, and since it is insoluble, it will reach the solubility limit. Since it's unsaturated, it has some of the properties of acetylene.

Now one last thing—we've spoken of solid acetylene. From our laboratory work, I would agree that it's a rather inert material if you have pure oxygen and pure acetylene. But if

we had a beaker here on the table with a few crystals of acetylene floating in the oxygen of the beaker and if we just passed over the surface of the beaker a very low concentration of ozone, the acetylene would immediately explode. This doesn't take very much ozone, obviously. Perhaps an ozonide is formed that sets off the rest of the acetylene. Acetylene is tough to trigger but its ozonide is easy. The unsaturated hydrocarbons may partake of some of this characteristic of acetylene.

Maley (Mine Safety Appliance Co.): In conjunction with the comment on infrared analyzers, I would like to state that there are about five plants now installing continuous nondispersive infrared analyzers with full-scale ranges of five parts per million or less and sensitivities of ±0.1 p.p.m. on the air intake streams. The first of these is going in shortly, and therefore, within the next six months there should be accumulated considerable data regarding the acetylene in air intake streams over a period of days or fortnights, or sudden surges that may occur. A device is also being tested that will enable continuous measurement of acetylene in the liquid oxygen pool by means of infrared analysis.

Farquhar (Foster-Wheeler Co.): In connection with the question Rogers brought up concerning sudden large influxes of hydrocarbons, the thought occurs to me that one method of dealing with the air stream has not been mentioned. It is scrubbing the cold air feed just before it enters the column. Liquid holdup on the trays should provide capacity to prevent break-through of temporarily high hydrocarbon concentrations into the column and subsequently into the liquid oxygen. Such a system has been used in an industrial plant; however, I don't know of any being offered now. I wonder if any of the air plant people would care to comment on the possibility of this being a feasible (both technical and economic) method of protecting oxygen plants?

Moderator: Anybody like to comment on that?

Kerry: I'm sure other design groups may want to answer that question—the only thing we do know is that we're well aware of the system of scrubbing air with rich liquid in order to remove hydrocarbons. With this, however, one has a purge loss and the objective of every design engineer is to produce oxygen at the lowest possible energy consumption. Oxygen itself is a utility in many metallurgical processes or chemical processes and it must be available at low cost and sometimes from a design standpoint so that purge loss may be comparatively high. Now I'm sure some other designers may have some comments on that.

Clyde McKinley (Air Products): An aspect inside of it is, if we know what's happening, then we have 90% of the problem solved—we can do something about it. Now a way of knowing what's going on at any point that you want to monitor in the plant would be to ascertain what is the total hydrocarbon or total acetylene content or total of any specific material you want to look for at that point. Some of you may have seen a hydrocarbon analyzer (Continuous Total Hydrocarbon Analyzer) which we have had on display here at this meeting, which operates on the principle of infrared measurement of all hydrocarbons totalized as CO_2. This technique can be used to monitor the hydrocarbon content on the entering stream or at any other points in the plant. If the tolerable level of a certain hydrocarbon is fifty parts per million and if your total hydrocarbon content is five, then you have the situation well in hand. Now gas chromatography was mentioned (by Karwat); this might be a supplementary technique to know occasionally what the make-up of the total 5, 10, or 50 p.p.m. hydrocarbons was. Of 50, perhaps 48 will be methane, a few tenths of a part per million will be acetylene, and the other hydrocarbons will account for the other 1.9.

Moderator: Thank you, Clyde. One more question.

Karwat (Linde Co., Germany): This concerns the method of cleaning the adsorbers of the desorbent. There could be quite great losses of liquid which would be wasted. Our normal practice is to warm up an adsorber which needs to be desorbed. This is done in system via pressure, and the liquid in the adsorber is sent back to the high pressure column. There is no loss of fluid.

Moderator: Well, we've heard a lot at this session about designing these plants safely, the theories behind the designs, and the reasons we do things. I still think, as Frank Kerry said before, that plants are as safe as the operators who handle them. If they're operated the way they're intended to be operated, you shouldn't have any trouble. We had our troubles, we have had explosions, but steps were taken to stop them and we haven't had one in five years. The air compressors are cleaned every 60 days. After a study of the water condition, intercoolers are washed every six months or a year. This is done on schedule regardless of production demands in the plant. When the time comes, we pull the switch and do our maintenance. We have thermometers on the discharge of air compressor cylinders so we know what the temperatures are. On machines that we are concerned about we have temperature alarms that shut them down if the water should fail and the operator doesn't notice it. I told you about our trial with synthetic oils. We've eliminated a lot of compressor fires, we know, and probably many fires we never knew we had. Several of the old high pressure four-stage air compressors had fires in the valve parts and in the connecting piping that one never knew about. In such cases, products of combustion go right over to the liquid oxygen, so by installing temperature alarms on some compressors we feel that we've caught many such occurrences. No mention has been made of filters after expanders—they should be there and they should be used. No mention has been made of washing of columns, at least the oxygen side of the reboiler. We feel these should be washed once a year and we do that. Trichlor, perchlor, carbon tet, or any good solvent can be used, but be sure you get rid of it afterwards. Nothing has been said about the defrosting time in a plant. One of the most critical times in the operation of the air separation plants is when you shut down to defrost. If you do it wrong you can cause an explosion in the reboiler. We feel the safest way to stop a plant is to drop the load on the air compressor and pull the switch and let the whole plant die. As the plant dies, the nitrogen on the upper trays comes down and dilutes the liquid oxygen in the reboiler and stops the boiling action and then we drain the liquid oxygen fast. I don't think I have anything more. I'm certainly pleased at the number (more than 200—Editor) who have shown such great interest in this subject. I hope a lot of good comes of it. It points out that the builders of this equipment are very aware of what has to be done to minimize trouble and I think they have done a very good job. Our experience has been excellent, but again, proper operation is awfully important.

At the Oxygen Plant Safety Conference held in connection with A.I.Ch.E.'s Boston Annual Meeting, E. Karwat of The Linde Co., Munich, Germany, read a statement which is the basis for the following communication.

OXYGEN PLANT SAFETY

E. Karwat | Höllriegelskreuth near Munich, Germany.

Gesellschaft fur Linde's Eismaschinen A. G. wishes to express to A.I.Ch.E. its appreciation for the opportunity to inform the chemical engineering profession about some of the experiences we have had in the field of safety involving almost 1,200 air separation plants of the tubular heat exchanger type and of almost 200 tonnage oxygen plants of the regenerator type.

I would like to open this discussion of hazards with comments on whether acetylene in solid state is particularly hazardous. A statement to the effect that it is not dangerous has appeared recently (*1*). Our opinion is that solid acetylene suspended in liquid oxygen exists in a high state of instability. Surely, the suspension in the violently boiling liquid is distributed in minute-sized crystals. In such cases (and we believe this happens quite frequently) one or another of such crystals may react with oxygen. Such small occurrences need not necessarily affect all floating crystals. Experiments, however, have shown that if with such a suspension there is introduced a strong initiating impact, e.g., by the explosive reaction of some tenths of a gram of solid acetylene or by the detonation of a primer cap, then all suspended little crystals will explode.

During a standstill, single crystals accumulate to greater bulks. This may happen in the upper part, in the middle section, or in the lower part of a vessel, according to the degree of admixture of solid CO_2 and the adherence of gas bubbles. Each particle reaction of a little crystal will then affect the whole bulk of the acetylene and become an explosion. We have observed that the explosion of 100 grams of solid acetylene with liquid oxygen smashes heavy thick-walled vessels.

In addition, we have come to regard with suspicion even dilute solutions of acetylene in liquid oxygen which are free from crystals. For, just as the boiling of a salt-solution creates a ring of crystals on the heated wall of the container, it is likewise possible that acetylene crystals will gradually deposit on surfaces where the boiling oxygen only periodically comes into contact with parts of the nitrogen condenser tube surfaces. These acetylene crystals will from time to time be wetted by liquid oxygen, with thin films remaining on their surfaces, and it is in just this state that a stoichiometric-explosive reaction will, as observed, most easily occur. Prior to the use of acetylene adsorbers, we occasionally observed accidents where every tube in the nest in the main condenser was demolished by acetylene explosions at exactly the height of the liquid level.

Causative Agents Most Important

In discussing explosion hazards, we believe it important to focus more attention on the causative agents providing the explosive medium rather than on the mechanism that serves to trigger or initiate the explosion to take place. A causative agent would be an explosive material, e.g., acetylene or butylene. Triggering or initiating effects can be manifold: mechanical influences, jerky evaporation after periods of standstill, formation of sparks caused by electrostatic charging, drying up of solutions in cavities, diminutive primary-ignitions, and finally the presence of specifically reactive substances which have likewise been referred to (*1*), such as radicals, nitrosates, and ozone. We are also of the opinion that their number is so great that, after having explored 20 different initiating effects, no one could be sure whether there would not be another still undiscovered.

Approaching the problem on the basis of initiating effects means then that there is no safety. Safety, however, is to be had when the explosive causative agents are eliminated and when unstable explosive materials are removed until only a harmless amount remains. Therefore, we attach great importance to achieving possibly complete removal of acetylene as the most unstable of all hydrocarbons—without disregarding other substances explosive with oxygen, such as hydrocarbons condensing in solid form (e.g. propane, butane, and in addition, hydrogen sulphide and carbon oxysulfide). The explosive limit of ozone in liquid oxygen is about 18 per cent by volume. As an explosive material by itself in air separation plants, therefore, ozone is out of question, although we agree that it is dangerous as an initiating agent when acetylene is present in liquid oxygen. Ozone has been found in krypton plants but not, to our knowledge, in liquid oxygen of tonnage oxygen plants. We are, however, concerned with the unstable compounds of ozone known as ozonides, and believe that efforts should be intensified to identify and remove them if they do exist in oxygen plants.

The hypothetically dangerous products of photochemical reactions of nitrogen oxides with organic materials (*2*) have mostly high molecular weights, with vapor pressures from 4 to 7 decimal points lower than those of acetylene and other light hydrocarbons. Up to concentrations of 0.001 p.p.m. they should be readily condensed in the regenerators and evaporated like the carbon dioxide in those cycles which employ regenerators. It might be expected that the non-condensed portion would be retained in the acetylene adsorber and that remaining traces would leave the separator via the auxiliary condenser and acetylene separator. The organic nitrogen dioxide compounds are of acid character and should be washed out by caustic, if the removal of carbon dioxide is effected by means of caustic. These, however, are

only assumptions. Until now, such organic nitrogen compounds have not been found by our organization in the main condensers of air separators. In my opinion it is desirable to prove their presence in liquid oxygen prior to their being presumed to be a cause of explosions and work in this direction should be undertaken. Until such proof is established, I must insist that the oxygen plant's enemy number one is acetylene.

Nitrogen oxides are normally present in waste gases and thus also in industrial air. They are found in the liquid oxygen of the air separator and mostly in the acetylene separator in p.p.m. concentrations. It has, however, been observed for a long time (without any hazard resulting) that they have been present in such large quantities as to impart to the liquid oxygen a greenish-blue tint, and to appear in the desorbed gas of the acetylene adsorbers as clouds of brown vapors. However, it must be considered that a stoichometric mixture of NO with liquid oxygen will react after initiation with a primer cap, but only with low free energy. Whether or not they would react in the bath of liquid oxygen with unsaturated hydrocarbons at the very low temperature is being studied at present; ethylene does not react. They are, however, disagreeable because of their corrosion effects and possible reactions succeeding corrosion (e.g. formation of Cu_2C_2).

Comprehensive information has been gathered on vapor pressures at very low temperatures of the C_1 to C_4 saturated and unsaturated hydrocarbons, on their solubility in liquid oxygen, on their gas-liquid partition in solution, on the explosion behavior of single-phase liquid solutions and of the two-phase systems solid-solution or liquid-liquid, on the mutual solubility of such hydrocarbons at liquid-oxygen temperature, and on their adsorption from solutions—all of which data are available to us for discussing hydrocarbon problems. I will not endeavor to elaborate on this point except for a few details: the higher the C number the lower the solubility (from CH_4 ∞ to $nC_4H_{10} \sim 175$ p.p.m.); a double-bond will lower the solubility (C_2H_6, 12%; C_2H_4, 1.8%); mixtures of propane and oxygen show a two-phase liquid system with $\sim 1\%$ C_3H_8 in liquid oxygen.

The explosion violence of a hydrocarbon in liquid oxygen solution diminishes with decreasing concentration. Therefore the real danger comes from the two phase system: solid-liquid or liquid-liquid.

No general rule can be given for all of these "light" hydrocarbons; each of them should be treated individually. This means also that analytical work on the contamination of air or liquid oxygen must show each hydrocarbon individually and not only an average C-number. Gas chromatography lends itself as an appropriate method.

Design Factors

As to precautionary measures to prevent plant explosions, the adsorption of the acetylene on silica gel as in use in our plants since 1943 is of primary importance, according to our experience. In the vicinity of carbide plants, where acetylene accumulates in the air, we use adsorbers arranged after the air stream passes through the first cooling steps with good results. The adsorbers not only remove all of the carbon dioxide from the air, making caustic scrubbing unnecessary, but also reduce high concentrations of acetylene to traces.

Vaporizers

We have been installing in all of our major air separation facilities since 1927 (with good results) vertical-tube auxiliary condensers for liquid oxygen located away from the main columns for their protection. We safeguard the auxiliary condensers against accumulation of solid acetylene in the course of oxygen evaporation by the operating rule that, in large plants, the acetylene content in the main condenser must be kept below 0.1 p.p.m. and that, in addition, 0.1 to 0.5 per cent of the produced oxygen must be withdrawn from the separator in liquid form.

Vertical tube evaporators at which the liquid oxygen is boiling within the tubes while gaseous nitrogen is brought to condensation at the outside of the tubes were installed by us into several small installations in 1928. This system, however, proved to be more sensitive to acetylene than did the normal evaporators with the liquid oxygen bath boiling outside and gaseous nitrogen condensing within the vertical tubes.

As far as safety is concerned, the forced-feed countercurrent film-vaporizer system referred to in a previous publication (*1*), appears to us to afford no advantage but actually certain disadvantages in apparent higher acetylene concentration in the vaporizer and the trays of the low pressure column compared to the gravity-fed main condenser with a vertical-tube auxiliary vaporizer system.

Lubrication Oil

The formation of acetylene in air compressors has been investigated. Quantities of acetylene formed from oil were found to be so insignificant that, compared to the natural acetylene, they are believed to be of no importance. Entrainment of oil into the separation apparatus is but of little importance where gaseous oxygen only is produced, but it is exceedingly disagreeable when producing liquid oxygen. For, when treating liquid oxygen containing oil, considerable efforts must be made to avoid oil explosions in the gaseous high pressure oxygen after evaporation.

Catalytic Removal of C_2H_2

Catalytic oxidation of the hydrocarbons prior to the air separation has been investigated by us for some time. It appears that, from a technical point of view, it can be done well. However, catalytic plants are still too expensive.

We are thus compelled to design separation plants so that concentrations of acetylene higher than 1 p.p.m. can be tolerated. With regard to tonnage plants with regenerators, a variety of new problems arise: condensation and evaporation of hydrocarbons (especially acetylene) on the filling mass of the regenerators, thickness of condensate films, their sensibility to sparks in the presence of gaseous or liquid air, and means for preventing unforeseen accumulation of dangerous material. We are studying these problems. It seems that in relatively simple cases practical industrial solutions can be proposed.

In standard medium air separation plants silica-gel adsorbers inserted in the air stream precooled to its carbon dioxide dew point offer good protection against hazards even from highly contaminated air, besides dispensing with the use of caustic scrubbing for decarbonization as already mentioned.

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the present status of

ELECTRIC MEMBRANE DEMINERALIZATION

*William E. Katz** | Ionics, Incorporated

A substantial cost break-through has been achieved in saline water conversion. An electric membrane process, operating on saline waters having salinities up to approximately 5,000 p.p.m. total dissolved solids, can now produce potable water in quantities up to several million gallons per day, at total costs of less than $1 per thousand gallons and at investment costs of less than $1.20 per daily gallon. The exact costs vary with the salinity of the water to be treated, size of plant, and other factors (*1, 2*). These conclusions are based on more than eight years of research and development, almost three years of field operating experience, and over 40,000 hr. of logged operating time on twelve electric membrane units. These units have operated on natural saline waters varying in salinity from 1500 p.p.m., which is just over the maximum U. S. Public Health Service limit for drinking water, to 35,000 p.p.m., which is the salinity of the Atlantic Ocean off the coast of Maryland. The saline waters treated had a variety of chemical compositions, including waters containing, besides their normal salt components, up to 1000 p.p.m. of alkalinity, 50 p.p.m. of hydrogen sulfide, 3000 p.p.m. of hardness, 10 p.p.m. of iron oxide, and the rich plankton growths of the fishing banks off Massachusetts. The temperatures of waters treated have varied from 120° F. in the deserts of the Middle East down to 32° F. or less in the Atlantic Ocean in the winter. The capacities of individual units have varied from 360 gal./day for a small refrigerator-sized prototype being tested at Annapolis, Maryland, for possible submarine use, to over 40,000 gal./day for a trailer-mounted unit operated on a brackish well of 2000 p.p.m. The largest unit currently under construction will, after its completion this fall, have an output of 86,400 gal./day of fresh potable water from a brackish well source of 3100 p.p.m.

* Based on a paper originally presented before the Seventeenth Annual Water Conference of The Engineers' Society of Western Pennsylvania.

Other Chemical Process Applications

In addition to water treatment, the ion-exchange membrane technique appears promising for an increasing number of applications in the chemical processing field. A good example is the removal of undesirable salts from organic solutions. Such applications include the removal of potassium sulfate from sugar solutions and the elimination of other impurities during the production of dextrose from starch and glycerine.

Other important potential uses are in the preparation of chloride-free caustic and in the potential deacidification of solutions. The latter case is especially interesting since, if an acid-base reaction is used to accomplish this deacidification, there is generally a residue of undesirable salt left in the solution.

Multiple-membrane units may be used to produce continuous separations of fast-moving from slow-moving

HOW CLOSE IS LARGE-SCALE SEA WATER PURIFICATION?

In 1952, Congress, under the Saline Water Act, appropriated $10,000,000 for the subsidy of experiments aimed at the development of economic methods of using sea or brackish water to relieve our increasingly serious shortage of fresh water for municipal and industrial use as well as for selective irrigation.

According to current reports from the Department of the Interior, the government-sponsored program is to be continued until 1966 and will involve more than twenty separate research projects. Some of the work is being carried out by private companies and some at the Saline Water Laboratories of the Department of the Interior at Denver, Colorado.

Within five years, the Department's Saline Water Conversion Program expects to see the use of sea water for industrial purposes in coastal regions and the use of brackish water for municipal use and irrigation in inland areas of the country.

Progress to Date

Today, five years after the 1952 Congressional appropriation, while substantial progress can be reported in some areas of work, the outlook is somewhat mixed. For example, it has not yet been demonstrated that any of the methods under consideration can desalt sea water to normal potability limits for less than about $2 per 1,000 gallons. An average figure for present municipal water supplies is in the neighborhood of 30 cents per 1,000 gallons. It can be seen, therefore, that use of sea water to supplement the water supply of cities such as New York or Los Angeles is probably some distance in the future. However, in arid regions where fresh water is scarce and costly smaller installations may well prove an invaluable source of potable water.

The situation with regard to brackish water is much more encouraging. In the first place, availability of brackish water sources is much greater in the United States than is generally realized. In the second place, several of the techniques now under development show promise of fairly short-range success. In particular, the ion-exchange membrane process, which is described in detail in the accompanying article, is claimed to offer many technical and economic advantages.

In addition to the ion-exchange membrane process, other methods worthy of special mention are:

1. Distillation, using a combination of vapor compression and the principle of the Hickman-type still, will be explored at the Denver Saline Water Laboratories of the Department of the Interior when equip-

ions. This method has been demonstrated in the separation of barium from barium-calcium mixtures and in certain amino acid separations, but costs are still high.

In the nuclear field, these membranes may be used as diaphragms in an electrolytic cell to reduce uranyl solutions to uranous, while simultaneously precipitating the tetrafluoride (green salt). In combination with conventional ion exchange, this process yields significant separation of uranium from impurities. In yet another application, ion-exchange membranes, employed in an electrolytic cell, permit the removal of nitric acid, aluminum nitrate, and zirconium fluoride from radioactive nuclides by electrodialysis.

Process Principles and Equipment

The basic principle of electric membrane demineralization is the movement of ions in an electric field through special membrane barriers, thus accomplishing the transfer of salt from one solution to another. Successful operation of the system depends not only on the use of electrical energy to create directed ion motion, but also on the use of barriers which will prevent back-motion of transferred salt and which will not allow the passage of water.

Ion-transfer membranes are large, thin sheets of ion-exchange resin. Two types are available, one of which conducts electricity by transfer of cations, the other by transfer of anions. The membranes are impermeable to liquid and are chemically stable in acid and alkaline media.

Fig. 1. Standard Ionics electric membrane stack containing 300 18 × 20-in. membranes and 300 "spacers."

Fig. 2. Assembling standard membrane stack. One of the membranes is about to be placed over a "spacer."

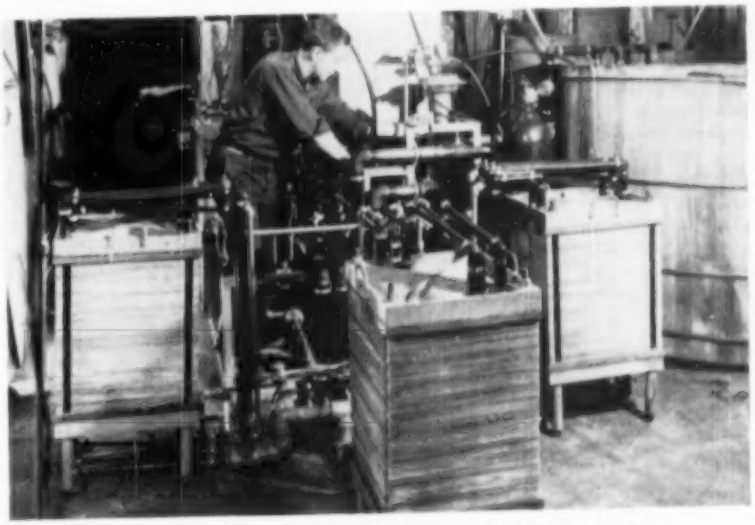

Fig. 3. The three operating stacks of an Ionics Series 9008 demineralizer.

The water to be purified flows in a thin film of perhaps 1 mm. thickness between two sheets of ion transfer membranes. The electrical current (usually 220 v. d.c.) forces the salt particles through the membranes, leaving purified water behind. In the adjoining compartments, the salts removed are concentrated in a second stream of water which is eventually "blown down" to waste at a higher concentration than the raw water fed.

A practical electric membrane apparatus is made up of a number of membrane stacks. A standard membrane stack, manufactured by Ionics, Incorporated, contains 300 ions transfer membranes, each 18 × 20 in., which form the walls of 300 1 mm.-thick water compartments. In 150 of these compartments, the saline water is being purified and in the other 150, which alternate, the salts are being accumulated in the blowdown or flushing stream. The capacity of the standard Ionics membrane stack is 20 gal./min. of water to be purified, with a demineralization of 40-50 per cent of the entering salts and minerals (Figures 1 and 2).

Large, fixed electric membrane plants are made up of series and parallel arrays of standard stacks with the required interconnecting piping, wiring, pumps, valves, and controls. The placing of stacks in parallel increases the flow rate of purified water in multiples of 20 gal./min. The placing of stacks in series gives demineralizations of greater than the 40 or 50 per cent achieved in a single stack. Thus a plant with two stacks in series will remove 64 to 75 per cent of the salt entering; a plant with three stacks in series will remove 78 to 87 per cent, etc.

ment now in process of fabrication by the Badger Mfg. Co., Cambridge, Mass., is completed. (This type of still has previously been used successfully in the separation of vitamins.) It is claimed that the centrifugal principle of this equipment will make possible operation at temperatures as low as 125° F. Capacity will be 25,000 gal./day of fresh water from 75,000 to 100,000 gal. of sea water.

2. International Nickel Co. is in the process of constructing a pilot plant at its test station at Wrightsville Beach, N. C. The plant is expected to be completed in approximately nine months. It will employ long-tube calandria evaporators similar to those used by salt manufacturing companies. This unit will attempt to reverse the usual procedure by recovering water instead of salt and by minimizing salt scale accumulation.

3. A pilot plant will be erected in San Diego, Calif. to test the practicability of solar distillation.

4. Carrier Corp., at Syracuse, N. Y., is investigating the possibility of separation of fresh water from salt by freezing. This process, however, is said to be only in the laboratory stage.

Table 1.—Water Analyses Before and After Treatment at Patrick Air Base *

	Before p.p.m.	After p.p.m.	Per cent removed
Total dissolved solids at 103° C.	1,566	455	71
Total hardness as $CaCO_3$	546	145	73
Alkalinity as $CaCO_3$	108	66	38
Iron, Fe	0	0	0
Sulfate, SO_4	172	94	45
Chloride, Cl	612	159	74
Calcium, Ca	118	29	75
Magnesium, Mg	61	18	70
Fluoride, F	0.25	0.15	40

* Courtesy of the Florida State Board of Health.

Table 3.—Specification Sheet and Cost Estimate for 2 Million Gal./day Plant

Design Basis

Feed water	1,600 p.p.m. TDS
Product water	500 p.p.m. TDS
Total flow to unit	2.4 million gal./day
Required blowdown	0.4 " " "
Product flow	2.0 " " "

Description of Unit

Continuous flow	70 Stacks per stage
Automatic operation	2 Stages
Complete with housing	140 Stacks in plant

Breakdown of Installed Costs

Membrane stacks	$ 700,000
Building—12,200 sq.ft. at $10/sq.ft.	122,000
Labor—33,000 man-hours at $3/hr.	99,000
Interconnecting piping	76,000
Control panels, wiring, instruments	49,000
Sand filters	50,000
Pumps	32,000
Metering equipment	25,000
Tanks—chemical and surge	14,000
Rectifier—300 kw.	30,000
Engineering, fees, contingencies	203,000
Total	$1,400,000

Breakdown of Operating Cost/Thousand Gal.

Membrane replacement	15
Electrical energy at 1¢	7
Operating and maintenance labor	4
Other repair parts	4
	30
Capital charges on 25 year—3% basis	12
	42

Recirculating units containing two, three, or more stacks in parallel are also manufactured (Figure 3).

Actual Field Operation

Early in 1956, Ionics ran a field test on a Model 300 B demineralizer at Patrick Air Force Base, near Cocoa Beach, Florida. A virtually inexhaustible supply of brackish water containing approximately 1600 p.p.m. total dissolved solids underlies this base, which is situated on a narrow sandy island completely surrounded by sea water (see Table 1).

The purpose of this field test was to indicate the reliability and operating requirements of such equipment in continuous operation on the actual water existing at Patrick. For the test, a Model 300 B was installed at the base, and operated on base water containing 1600 p.p.m. of total dissolved solids (640 p.p.m. chlorides).

The unit was operated over most of the demonstration period to produce water containing 500 p.p.m. total dissolved solids (160 p.p.m. Cl). Approximately 230,000 gal. of water was produced at this salinity. For other periods of intermediate length, the unit was also operated to produce 850 p.p.m. TDS water (330 p.p.m. Cl) and 300 p.p.m. TDS (80 p.p.m. Cl) water from the same source.

Table 2.—Summarized Operating Data on Model 300 B (One-Stack) Demineralizer [from Field Test at Patrick Air Force Base]

	Run I	Run II	Run III
Raw water total solids (p.p.m.)	1,600	1,600	1,600
Product water total solids (p.p.m.)	850	500	300
Raw water chlorides (p.p.m.)	640	640	640
Product water chlorides (p.p.m.)	330	160	80
Per cent removed (total solids)	47	69	81
Production rate, gal./min.	20	10	7.5
Blowdown rate, gal./min.	1.7	1.7	1.7
Pumping power, kw.	2.0	2.0	2.0
Electrodialysis power, kw. (as AC feed)	2.0	1.8	1.7
Total power, kw.	4.0	3.8	3.7
Energy consumption (kw.-hr./1,000 gal.)	3.3	6.3	8.2

Table 2 summarizes operating power requirements and production rates for the three salinity reductions, as obtained over the test period.

Over the test period, down time for maintenance was substantially zero. Operating labor consisted of ten minutes daily for filter cartridge replacement and one hour weekly for chemical make-up. Neither of these labor requirements would be significant in large-scale plant operation, where automatic control of filtration and chemical make-up would be provided.

A complete chemical analysis of the treated water is shown in Table 1. This chemical analysis indicates that the over-all demineralization with respect to total dissolved solids was 71 per cent. The removal of the individual components is shown in the table.

Scale-Up of the Data for a 2 Million gal./day Plant

As a result of simple tests such as that conducted at Patrick A.F.B., it is possible to predict accurately the size, energy consumption, and both operating and investment costs of any larger plant based on the same membrane stack. There is no scale-up factor involved in the basic unit, the stack, since this same stack is used both in the very small test plant and in the very large 2 million gal./day plant. The only scale-up involved is in the pumps, piping, valves, and manifolding system.

A 2 million gal./day plant which would have a flow rate of approximately 1400 gal./min. of purified water would require 70 standard stacks in parallel each having a capacity of 20 gal./min. The required reduction of 1600 to 500 p.p.m. (a 69 per cent demineralization) can be accomplished as is shown in Table 3 in two stages of demineralization, so that the total plant for 2 million gal./day would contain 140 stacks. The installed price of this plant including buildings, all pumps, pipes, valves, labor of erection, engineering charges, contractors' fees, contingencies, and stacks themselves is estimated at $1,400,000. The plant would produce 500 p.p.m. water at a total cost of $.42 per thousand gallons. A breakdown of the investment and operating costs and other specifications are shown in Table 3.

Comparative Costs by Distillation

Published cost estimates for the most recent large water distillation plants

to be designed (Kuwait, Aruba, and Morro Bay) range from a predicted \$1.75 to \$2.80 per thousand gallons (see Figure 4) (*3, 4, 5*). These estimates are for plants having capacities up to 2.7 million gallons per day. Furthermore, the required investment cost is high—from \$2.80 to \$3.70 per daily gallon of capacity (see Figure 5) (*3, 4, 5*).

In the U. S. in 1950 the mean price paid by consumers for delivered municipal water was \$.20 per thousand gallons, and the mean book value of municipal water systems was approximately \$.50 per daily gallon of capacity. The figures include distribution costs as well as production and treatment costs (*6*).

In the U. S., the cost of fresh water from vapor compression, multieffect distillation, or solar distillation processes as presently available for practical use has been placed recently somewhere in the range of \$1.22 to \$3.67 per thousand gallons (*7*).

Technical objections can be raised to the comparison of the costs of the electric membrane process on brackish waters with the costs of other processes which apply to sea water or brackish water. The electric membrane process has costs which depend on salt content whereas most distillation processes have costs which are essentially independent of salt content. A user of fresh water is not concerned, however, with its original source but with how much he has to pay for the water. Present-day costs of the electric membrane process for brackish waters are already as low as probable future costs by distillation. Therefore, the water user who needs to convert saline water can do as well today using the electric membrane process as he will be able to do perhaps five or ten years in the future using distillation, if he is able today to find brackish water in the 1000-5000 p.p.m. range to treat. Brackish water, 1000-5000 p.p.m., is readily available in the Western U. S., Middle East, South and North Africa, and parts of Australia. Hence, this restriction on the most economical range of the electric membrane process does not rule out many practical cases.

Brackish water, in fact, has several attractive characteristics as compared with sea water, besides its lower salt content.

1. While sea water is available only at the sea coast, brackish waters are widely distributed not only near the sea coast but inland as well, thus cutting down pipeline costs.

2. While sea water is available only at sea level and must be pumped to the land elevation where its use will occur, underground brackish waters usually occur at an elevation higher than sea level and sometimes even under artesian pressure.

3. While most underground brackish waters emerge clear and sterile, sea water is subject to pollution by human and industrial wastes and, in wartime, by purposeful contamination with radiological and biological agents by enemy action. Furthermore, even when unpolluted, most sea water contains relatively rich growths of plankton and animal life and is highly corrosive to handle.

For these reasons, it would seem that sea water is perhaps the least attractive alternative in the over-all economics of supplying land areas with fresh water. This conclusion is particularly important since a process to desalt brackish water economically is now a commercial reality.

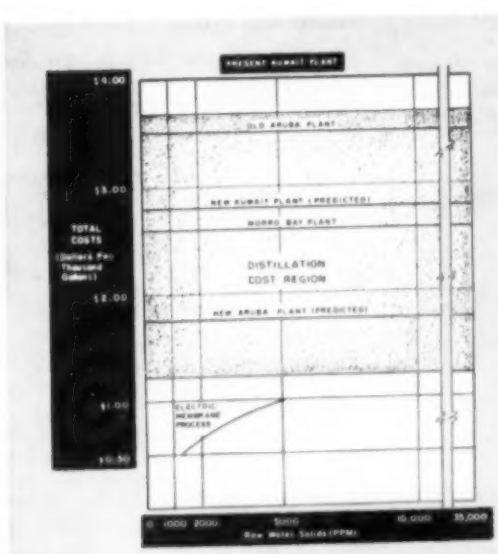

Fig. 4. Total costs of various water supplies and processes.

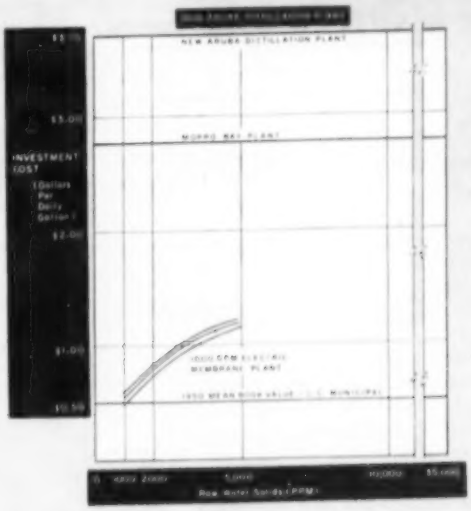

Fig. 5. Investment costs of various water supplies and processes.

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MIXING PATTERNS in HELICAL-FLIGHT dry-solids MIXERS

Mixing patterns were measured in an industrial helical-flight dry-solids mixer, magnesium sulfate being used as a tracer in sodium bicarbonate. Fluctuations in composition were observed which diminished with time but did not disappear after prolonged mixing. Changes in the main variables of operation produced little effect except when the size of charge was halved. The rate of mixing at the surface was found to be roughly eight times that below the surface. Means of improving the performance of this type of mixer are suggested. The results are explained by a mechanism in which coarse mixing takes place by movement of slugs of powder through the material, and fine mixing by turbulence at the boundaries between the moving and stationary material. Local density changes in the wake of the moving blades oppose mixing by causing segregation through a process analogous to jigging.

J. A. A. Greathead and W. H. C. Simmonds | University of Durham, Kings College, Newcastle-on-Tyne, England *

In recent years little has been published on the performance of industrial mixers (*2, 6, 10*). The object of the present work was therefore to study the mixing process in a typical mechanically agitated industrial mixer in order to gain some insight into the relative importance of different factors under commercial conditions.

The method chosen was to follow the mixing of a small quantity of an easily identified material, magnesium sulfate, in a helical ribbon-type industrial mixer containing an anhydrous, nonhygroscopic, free-flowing solid—sodium bicarbonate—of reproducible particle-size distribution. The magnesium sulfate was spray-dried, the size and density of the particles being independently varied by altering the conditions of spray-drying. Together with a variable-speed drive on the mixer this allowed investigation of the effect of several production variables.

Equipment

The mixer was a Gardner Rapid mixer consisting of a U-shaped trough with internal dimensions, 4 ft. long, 1½ ft. wide, and 2¼ ft. deep at the center line, constructed of cast iron with a phosphor-bronze lining. It was fitted with a lid and a central discharge gate at the bottom and had a normal working capacity of 200 lb.

The arrangement of the phosphor-bronze agitator blades is shown in Figure 1. The six blades, each about 1¼ ft. long by 1½ in. wide and ⅜ in. thick, occupied approximately 1 ft., 2 in., of the shaft length, with approximately ¼-in. clearance from the curved bottom of the mixer, and formed portions of helices of equal pitch.

As shown in Figure 1, the six blades were arranged in two sets of three of opposite hand, the end blades pushing material toward the center of the mixer. The effect of rotating the agitator was therefore to raise and move part of the material first in one direction then in the other during each revolution.

Concentrations down to 20 p.p.m. were reproducibly analyzed, the standard oxine method being found satisfactory for the determination of magnesium in the presence of widely varying amounts of sodium, provided that the gravimetric and not the volumetric procedure was followed (*9*).

Operating Procedure

Sodium bicarbonate and magnesium sulfate of measured particle-size distribution and bulk density were drawn from bulk supplies set aside for the experiments. The mixer was charged with 199 lb. of bicarbonate, and run for 1 min. to establish its characteristic distribution (shown in Figure 2). It was stopped with the blades always at the same point while 1 lb. of magnesium sulfate was added through a chute. The mixer was then run, with the lid closed, on a definite time schedule for total times of 1, 2, 4, 8, 16, up to 128 min., at the standard speed of 60 rev./min.

After time had been allowed for dust in the mixer to settle, samples were taken with glass vials or a thief for the near-surface and subsurface positions respectively. A suitable sample size proved to be 30 g., and no sample was taken near the point of addition of the magnesium sulfate at the start of mixing.

Experimental Results

Initial runs were made to determine the best point of addition of the magnesium sulfate and the minimum number of sample points to evaluate the mixing pattern.

A typical mixing pattern when the magnesium sulfate was added at one corner is shown in Figure 3. The magnesium content at any given sampling point tends to oscillate as the magnesium is carried along the mixer, but there is a considerable spread in the results around the mean value of 0.5%. This was not improved by discharging the mixer, recharging, and continuing mixing for 2 hr. more.

The spread around the mean value was reduced when the point of addition was moved to the center of the mixer; however, satisfactory results were obtained only when the point of addition was on the "low" side of the mixer, i.e., the side on which the mixer blades descend into the powder. The mixer was also found to act symmetrically and so samples might be taken from only one half the mixer. The positions selected are shown in Figure 4; positions *a* and *c* showed the greatest deviation from one another, and in general from the mean value, while position *b* gave values which were an approximate average of the seven positions used in the initial runs.

Mixers in Series

Mixing of solids is a balanced process, the over-all result being a combination of a rate of mixing, a rate of segregation, and a rate of attrition. There was some evidence from the early runs that with this mix and mixer a fairly high degree of mixing was achieved in the first few minutes but that there was not much improve-

* Dr. Greathead is currently with Lobitos Oilfields Ltd., Ellesmere Port, Cheshire, England, and Mr. Simmonds with Canadian Industries Limited, Montreal, Canada.

ment during the rest of the 2 hr. of mixing. (Compare Figure 3.) An attempt was therefore made to break up the mixing pattern by discharging and recharging the mixer at different times during the 128 min. of total mixing time. This procedure is equivalent to operating two identical mixers in series. The results are shown in Figure 4 and Table 1.

The graphs show the rapid initial mixing in 2 to 4 min. and a slight improvement after 128 min. of total mixing. The effect of discharging and recharging the mixer in each case was to cause some deterioration in the mix at the sampled points, presumably because of segregation during discharge and recharge.

EFFECT OF THE DENSITY OF THE MAGNESIUM SULFATE

The standard spray-dried magnesium sulfate used in these tests had a bulk density index of 24.* The effect of replacing this by material of higher and lower index (27 and 22 respectively) is shown in the center section of Figure 5. The times taken for all samples to be included in a band of $0.500 \pm 0.050\%$ were very similar (2 min.), evidence that variations in the bulk density of the tracer did not significantly alter the results.

EFFFECT OF PARTICLE SIZE AND PARTICLE-SIZE RANGE OF THE BICARBONATE

The effect of splitting the bicarbonate into large and small particle sizes (± 100 mesh B.S.S.) by use of normal, high- and low-density magnesium sulfate is also shown in Figure 5. Times for all the samples to fall within the $0.500 \pm 0.050\%$ band were virtually equal, although there is some indication that the coarse bicarbonate ($+100$ mesh) requires a slightly longer mixing time than the fine bicarbonate (-100 mesh). The most noticeable point is that particle-size variations within this range do not appear to be important.

In some of these tests the average magnesium sulfate content of the samples was higher than the expected value. Since this might have been due to a variation in magnesium content with depth, subsurface samples were taken and a new sampling position, *d*, on the "high" side of the mixer was used. These tests, however, did not reveal significant differences among surface, near-surface, and subsurface samples.

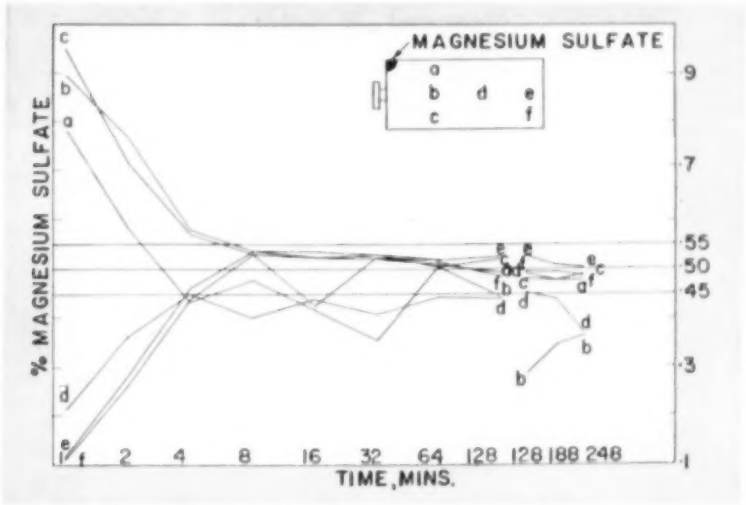


Fig. 3. Mixing pattern when magnesium sulfate is added in one corner.

EFFECT OF SIZE OF CHARGE

The effect of changing the size of charge from 200 to 100 and 300 lb. is shown in Figure 6. The surface samples reached the $0.500 \pm 0.050\%$ band rapidly in both cases, but below the surface a much longer time was needed for the same mixing to be achieved, the subsurface mixing with the smaller charge being particularly erratic.

EFFECT OF SPEED OF ROTATION

Changing from the normal speed of rotation of 60 rev./min. to 28 and 85 rev./min. results, as shown in Figure 7, in a curve for 28 rev./min. closely parallel to that for 60 rev./min., except that there is a wider scatter in the results for the first few minutes. At 85 rev./min. the scatter of the results is greater, which may be due

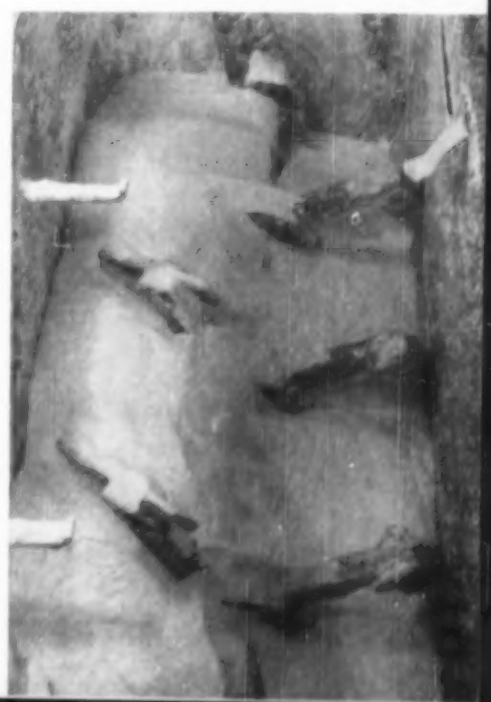
* The bulk density of spray-dried magnesium sulfate is measured more reproducibly as the sedimentation volume in carbon tetrachloride than by conventional methods.

Fig. 1. Arrangement of phosphor-bronze agitator blades.

Table 1.—Effect of Mixers in Series

Time of discharge, after minutes	Spread in magnesium sulfate concentration, %: Before discharging	After recharging	After 128 min.
2	0.013	0.079	0.015
8	0.044	0.047	0.019
16	0.032	0.037	0.032
32	0.038	0.109	0.013

Fig. 2. Distribution after 1 min. run with 199 lb. of sodium bicarbonate.



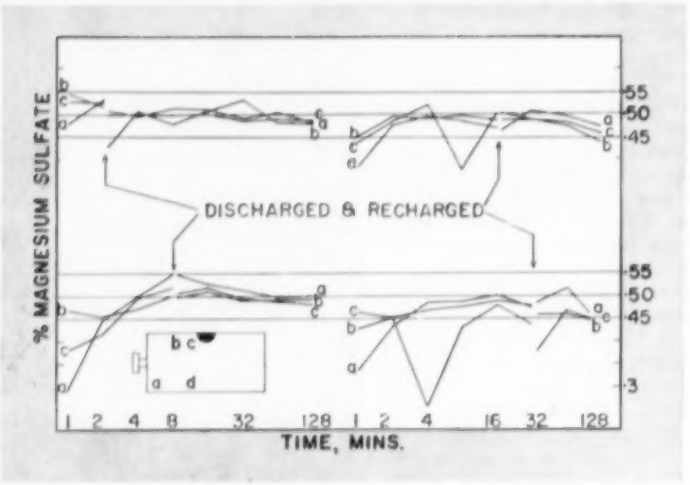


Fig. 4. Results obtained by discharging and recharging mixers at different times.

partly to powder being thrown into the air space in the machine at the higher blade velocities.

Test on a Large Mixer

In order to determine whether the results found with the small ribbon mixer were representative, a test was run on a large rotary vacuum mixer-dryer which had a working charge of 2,000 lb., ten times that of the small mixer.

The mixture handled in this Scott dryer-mixer comprised roughly equal proportions of sodium bicarbonate, tartaric acid, icing sugar, and magnesium sulfate. The final mixture is required to be slightly on the acid side, and determination of the free acidity after solution in water and removal of the carbon dioxide was used to measure the quality of the mix.

A suitable size of sample was determined by carrying out a statistical test with ½-, 1-, 2-, and 4-oz. samples taken in a definite order from the discharge stream of the mixer. A variance analysis of the results showed that neither the position of the sample in each series, the time the sample was taken, the size of the sample, nor the difference between pairs of samples was significant. A sample size of 50 g. (~2 oz.) was therefore chosen as the most convenient.

The normal operating cycle for these mixers involved a 20-min. charging time (materials added one at a time), drying and mixing for 1 hr., and discharging for 25 min. Samples could be taken only during the drying and mixing period, and limited access prevented them from being taken except at the points shown in Figure 8. These were respectively at two points on the two axes of the mixer 9 and 18 in. from the center point and at the center point, 9 in. down (A′) and as near the bottom as possible, by means of a long thief (A″). Samples

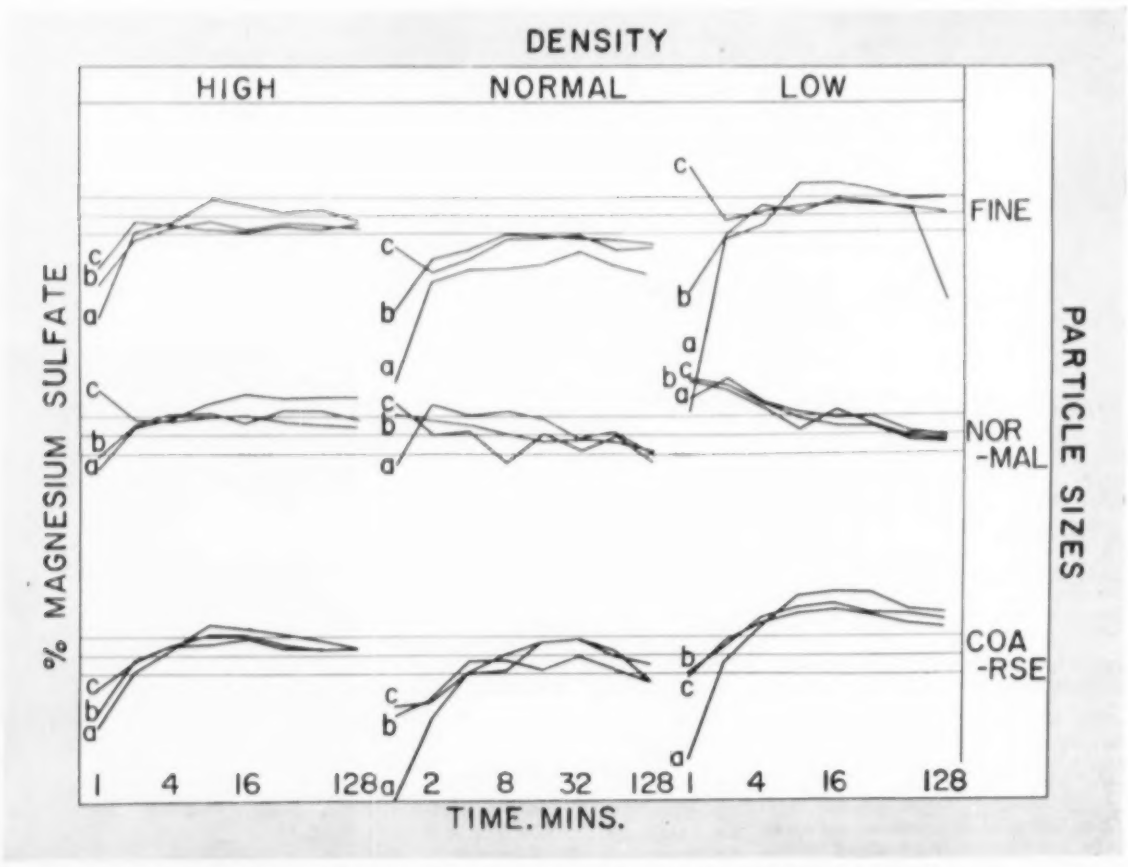


Fig. 5. Effect of replacing medium-density magnesium sulfate with higher and lower density grades.

were taken also at five points after the material left the mixer: at the discharge of the mixer, at two points in the conveying and elevating system, at the entry to a storage bin, and from the final filling machines.

The results of the samples taken inside the mixer are shown in Figure 8 and are similar to those observed with the small mixer. The same fluctuations noted previously occurred in samples taken at different points and this variation settled down to a figure of ±0.4% around the expected value of 1.51% excess acidity. Analysis of the variance of the samples taken from the discharge stream from the mixer showed that 95% of the values fell within the range of 1.61 ± 0.46% excess acidity. The quality of the discharge stream thus appeared to be slightly lower than that inside the mixer. (Compare the mixer-in-series experiments with the small mixer.) The change in quality during the subsequent handling of the mix is shown in Table 2. The results show a progressive deterioration in the quality of the mix in the course of discharging the mixer and conveying and elevating the mix to the storage bins, although some improvement occurs in the final step of filling the container.

Discussion of Mixing Pattern

The mixing pattern revealed by the tests in the small mixer is one of pockets or slugs of material being moved along and through the powder by the blades. The oscillations in magnesium content in the earlier stages of many of the tests show this clearly. As mixing proceeds, the oscillations subside but do not entirely disappear even after 2 hr. of mixing.

Mixing is shown to be most rapid in the surface layers. With the 0.50 ± 0.05% band used as the criterion 2 to 4 min. is required for surface mixing, whereas 16 to 32 min. is required for subsurface mixing. Resistance to movement is obviously least at the surface, where mixing can occur by spreading, and the figures suggest that resistance to movement through the powder is roughly eight times that at the surface.

The effect of changing the main production variables of revolutions per minute, particle size of the bicarbonate, and bulk density of the magnesium sulfate was small, but reduction of charge size had measurable results. This lack of effect is due partly to the small difference in true density (sodium bicarbonate 2.20, spray-dried magnesium sulfate ~2.0 g./cc.) and to the complex nature of the mixing process.

The effect of moving a blade through a powder is analyzed in Figure

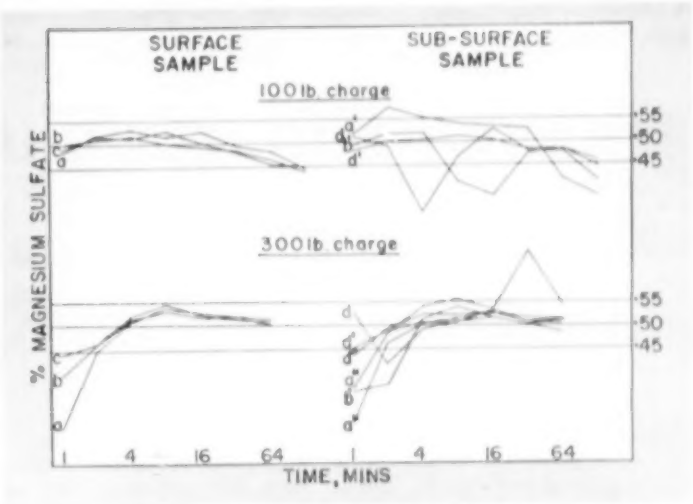


Fig. 6. Effect of particle size and particle size range of the bicarbonate, plus effect of size of charge.

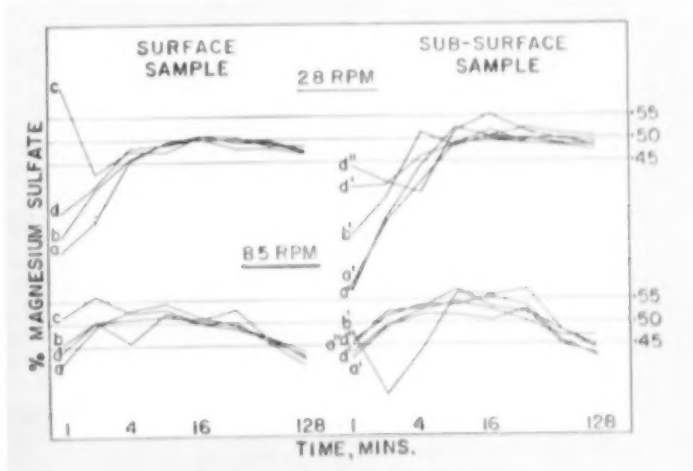


Fig. 7. Effect of speed of rotation.

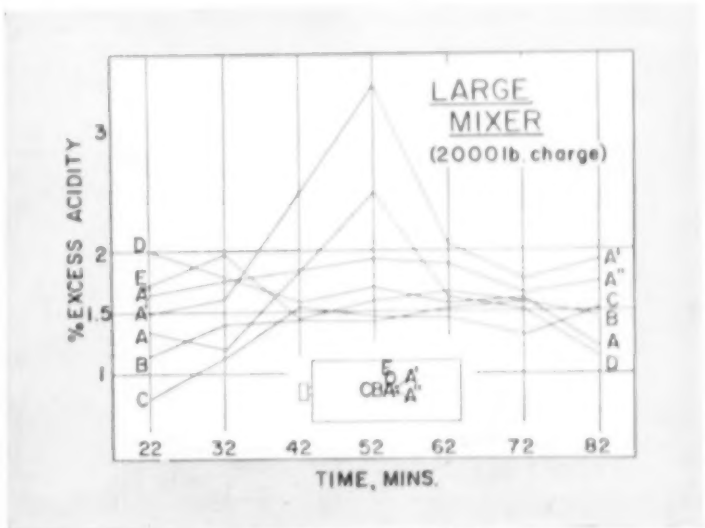


Fig. 8. Tests on a large (2,000 lb.) mixer.

Table 2.—Statistical Analysis of Samples from Large Mixing Operation, Sampling Points Expressed as Percentage of Excess Acidity

	At mixer discharge	At screen	After conveying and elevating	At entrance to storage bin	Filling machine
Mean value	1.61	1.56	3.20	2.35	1.44
Standard deviation	0.23	0.37	1.56	2.92	0.408
95% limits	±0.46	±0.74	+4.02 −2.22	±5.84	±0.82

9. Coarse and medium mixing is achieved by movement of slugs or pockets of powder through the rest of the material (mixing by shearing). At the boundary layer between these slugs or pockets and the rest of the powder turbulence occurs in the same way as with fluids, giving rise to local or fine mixing (mixing by diffusion). But at the same time the movement of the blade expands the powder and decreases the local bulk density. As the powder settles back behind the blade, segregation occurs by the well-known process of consolidation trickling (small particles trickling between larger particles of the same density and denser particles settling below lighter particles of the same size). In other words, the action of the blade is to pulse the mixture in exactly the same way as a jig does in ore dressing.

This analysis explains the main features of this type of mixer—rapid initial mixing followed by a slow improvement to a definite limit (in the present case around 0.50 ± 0.05%). It also sets up one criterion with which practical mixers may be compared. A perfect- or ideal-solids mixer should produce relative movement of two solids without local fluctuations in bulk density. In practice some fluctuations in bulk density are essential to allow particles to move past one another, and as long as this occurs only in a horizontal plane, mixing takes place, but in a vertical plane gravity comes into play at once and segregation can occur.

A possible way of preventing segregation in helical-flight mixers is to put an aerofoil section on the back of the blade as shown in Figure 9(ii) and thus prevent jigging action; an alternative would be to use more, thinner blades or bars and thus to reduce the effective volume of the segregating region S and increase the area for diffusion D while maintaining the slug volume A constant (Figure 9(iii)).

Coulson and Maitra (*3*) have shown that segregation can occur in nonmechanical mixers of the inclined-drum type,* and Peck (*8*) has shown that the cause of the local fluctuations in bulk density in this case is wave motion and eddying. The use of vibratory tables in ore dressing to effect separation of solids makes it clear that vibrations are also detrimental to mixing unless their amplitude is very small (as in mixing by ultrasonics).

Mixing bears some relationship to size reduction in that both bring about a change in the scale of the system together with an increase in interfacial area (*4*). It is well known in size reduction that different types of machines operate most efficiently over a limited range of sizes, and hence different types of mixer would be expected to operate with varying efficiencies in coarse, medium, fine and ultrafine mixing. Comparative studies, at which a start has been made (*1, 5, 7*), of the rates and degree of mixing of the same mixture in different mixers would be most valuable.

Similarly it is clear that designers should be informed of the tendency of the mix to segregate, as shown in the large-scale mixing test. Coulson and Maitra's test (*3*), or possibly a simple jigging type of test, could serve as a means of classifying mixtures according to type. (This problem is analogous to the problem of defining tough and brittle solids in size reduction.) Given such a test, the segregating tendency of solids-handling equipment could be evaluated. Current methods of minimizing segregation during the handling of mixtures have been reviewed by Work (*11*), but in particular the operation of discharging mixers seems to merit more analysis.

* A possible new ore-dressing machine. The requirements for ore dressing and mixing seem to be exactly opposite.

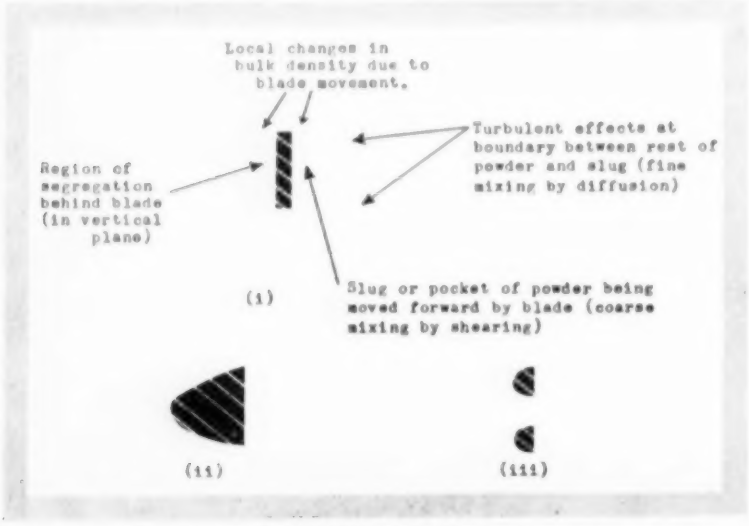

Local changes in bulk density due to blade movement.
Turbulent effects at boundary between rest of powder and slug (fine mixing by diffusion)
Region of segregation behind blade (in vertical plane)
Slug or pocket of powder being moved forward by blade (coarse mixing by shearing)
(i)
(ii)
(iii)

Fig. 9. Analysis of effect of moving a blade through a powder.

Acknowledgment

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Presented at A.I.Ch.E. meeting, Pittsburgh, Pennsylvania.

A FLUIDIZED BED PROCESS for the production of uranium tetrafluoride

The authors of the accompanying paper are concerned primarily with the development of a process technique for improving the reduction and hydrofluorination operations in the production of uranium tetrafluoride (green salt). Advantages of the use of single and multistage fluidized beds over methods now in use are illustrated.

N. M. Levitz, E. J. Petkus, H. M. Katz, and A. A. Jonke*

Chemical Engineering Division, Argonne National Laboratory, Lemont, Illinois

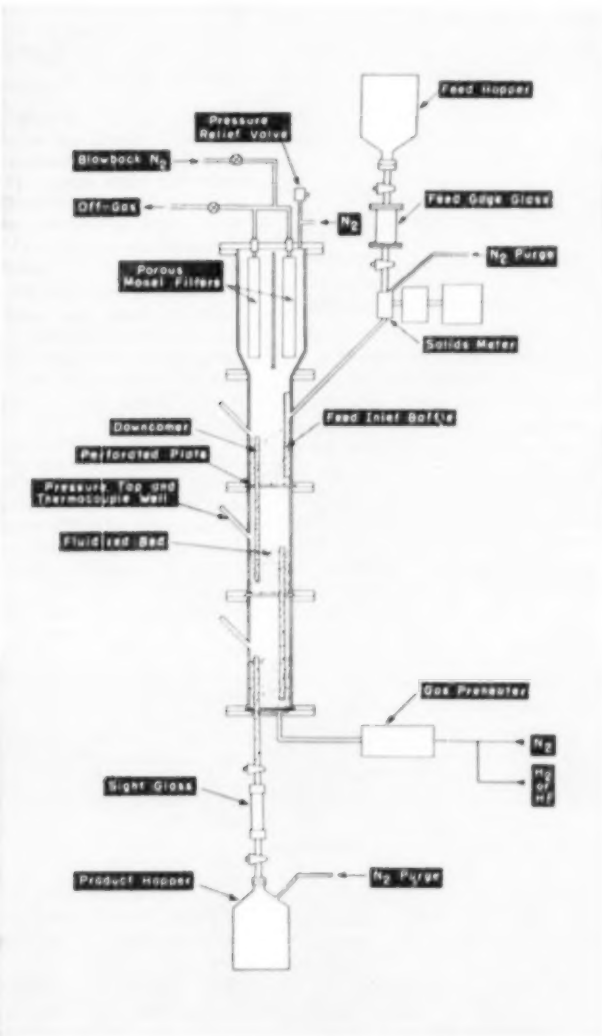

Fig. 2. Multiple-stage fluid bed reactor.

The continuing demand for large quantities of pure uranium metal for reactor fuels has promoted interest in the development of new and better processing techniques for the production of feed materials and for the recovery of spent nuclear fuels. The present processing technique involves solvent-extraction refining to remove impurities from ore concentrates or to remove fission elements from spent fuels. After the solvent-extraction step, a number of chemical operations are required to convert the purified uranyl nitrate solution to uranium tetrafluoride or uranium hexafluoride.

A block flow diagram of the process steps involved in this conversion is shown in Figure 1. Uranyl nitrate solution from the solvent-extraction refineries is converted first to uranium trioxide by evaporation and thermal decomposition, then to uranium dioxide by high-temperature reduction with hydrogen, and next to uranium tetrafluoride by reaction with anhydrous hydrogen fluoride gas. The tetrafluoride product may be used either for fluorination to uranium hexafluoride or for reduction to metal (*1*), such use depending upon whether or not the uranium is to be enriched by gaseous diffusion.

Much attention has been centered in the past on optimizing the solvent-extraction-refining operation. More recently the steps following extraction have come under careful scrutiny in an effort to minimize production costs. A technique for the continuous production of uranium trioxide from uranyl nitrate solution by fluidized-bed calcination has recently been developed (*2*).

* H. M. Katz is now at Columbia University, New York.

Table 1.—Size Distribution of Typical UO_3 Used in Fluid-Bed Experiments

Mesh size	Percentage
+40	0.2
−40, +80	17
−80, +100	43
−100, +200	30
−200	10

Table 2.—Effect of Temperature on Reduction Reaction

(Single-stage, batch runs)
Bed depth—9 in.
Gas velocity—0.5 ft./sec.
Run duration—4 hr.

Temp. (° C.)	Conversion (% UO_3)
525	94.1
575	98.0
700	99.1

Table 3.—Effect of Reduction Temperature on Rate of Hydrofluorination

(Single-stage, batch runs)
Bed depth—9 in.
Gas velocity—0.5 ft./sec.
Gas composition—60% HF, 40% N_2
Run duration—4 hr.

Reduction temp. (° C.)	Hydrofluorination temp. (° C.)	Percentage unconverted UO
525	450	5.1
560	450	5.0
575	450	2.5
700	450	33.9

Table 4.—Effect of Hydrofluorination Temperature on Reaction Rate

(Single-stage batch runs)
Bed depth—6 to 8 in.
Gas velocity—0.5 ft./sec.
Gas composition—60% HF, 40% N_2
Run duration—4 hr.
Reduction temp.—575° C.

Hydrofluorination temp. (° C.)	Percentage unconverted UO_2
390	15.5
450	2.5
575	1.6

Table 5.—Typical Continuous, Single-Stage Reduction Run

Weight of oxide in bed—17.3 lb.
UO_3 feed rate—3.2 lb./hr.
Bed temperature—575° C.
Gas composition—74% H_2, 26% N_2
Gas velocity—0.4 ft./sec.
Solids residence time—5 hr.

Running time (hr.)	UO_2 assay (%)
1.5	96.0
3	96.8
4.5	96.2
6	96.2
7.5	95.0

Advantages of Use of Fluidized Beds

As a possible means of reducing capital and operating costs, the use of fluidized-bed reactors to replace the other types of reactors now in use has been investigated. A major incentive for the development of the fluidized-bed technique for these process steps is that there is little limitation on the size of a fluidized-bed reactor. It is possible, therefore, to use one set of large reactors rather than a large number of small reactors as are used in the existing feed materials plants. An equally important advantage of the fluidized-bed technique is that uniform temperature control can be achieved and heat removal is simplified. The importance of these factors will become apparent from subsequent explanations. The absence of moving mechanical parts in the fluidized reactor is an additional advantage.

Chemistry of the Process

The chemical reactions for reduction and hydrofluorination are as follows:

$$UO_3 + H_2 \rightarrow UO_2 + H_2O + 43{,}000 \text{ B.t.u./lb. mole}$$

$$UO_2 + 4HF \rightleftharpoons UF_4 + 2H_2O + 82{,}000 \text{ B.t.u./lb. mole} \quad (3)$$

Both reactions are highly exothermic. In practice dissociated ammonia is used as the source of hydrogen for the reduction step.

The kinetics of the reduction and hydrofluorination reactions are greatly influenced by the prior history and the method of preparation of the uranium oxides. In addition to obvious factors such as the surface area and pore diameter of the oxide, the chemical reactivity is believed to be influenced by crystal structure, lattice deformations, surface sintering, and other factors which are not well understood. It has been found that the reactivity of the oxide can be increased in some cases by incorporating a small amount of certain impurities into the oxide during its preparation.

Since surface sintering and crystal growth can substantially reduce chemical reactivity, it is important to minimize these effects by avoiding local overheating and maintaining careful temperature control. The advantage of the fluidized bed in this respect is well known.

The hydrofluorination reaction is reversible, the rate of the reverse reaction increasing with temperature. The optimum temperature for the over-all reaction is a function of the water content of the gas phase, and in a countercurrent operation the optimum temperature varies from a higher value at the gas inlet end of the apparatus to a lower value at the gas exit end where the water content is high. For this reason it is highly desirable that the production process be carried out countercurrently in order to achieve maximum conversion with a minimum of excess hydrogen fluoride. In addition the required residence time of the solids in the reactor is minimized in a countercurrent operation. Since a single fluidized bed cannot be operated countercurrently, considerable experimental effort was spent in the development of a multistage, fluidized-bed reactor. The over-all program, however, included batch and continuous runs in both single and multistage reactors.

Experimental Equipment

Several fluidized-bed reactors were constructed to study the processing technique on a modest scale. Most of the work described in this paper was carried out in the bench-scale reactor shown in Figure 2.

This unit, of 3-in.-diam. pipe, is constructed of Monel and nickel. It contains three fluidized beds, each supported by a perforated plate containing 1/16-in. holes on 1/2-in. centers. Solids flow from the upper stages to the lower through downcomers which are 7/8-in. O.D. and extend 5 in. above the perforated plates. The over-all length of each stage is 10 in.

The reactant gas after being preheated enters at the bottom and flows upward through the three fluidized beds and into the disengaging section, where two porous Monel filters remove entrained dust particles. One filter is in use, while the other is being blown back for cleaning. Solids enter at the top through a solids feeder and are collected in a hopper at the bottom. For metering the small volume rate of solids required, a screw feeder made from an ordinary wood auger is used. The screw is turned by a variable-speed drive, and feed rates are controlled by speed and auger size. Each stage of the reactor is heated by a 1000-w. tubular electric heater on the outside wall, controlled by a variable transformer to maintain the solids at temperatures in the range of 400 to 600° C. In addition to the use of this reactor for the multistage experiments, the same unit was used for single-stage runs merely by removing the upper two decks and downcomers.

Experimental Results

Since the previous history of the uranium trioxide used in the fluidized-bed experiments was different from that used in the production plants, having been produced by fluidized-bed calcination of uranyl nitrate solution, it was necessary to perform a number of preliminary experiments to deter-

Table 6.—Typical Continuous, Single-Stage Hydrofluorination Run

Weight of UF_4 in bed—16.8 lb.
UO_2 feed rate—1.98 lb./hr.
Bed temperature—450° C.
Gas composition—84% HF, 11%N_2, 5% H_2
Solids residence time—8.5 hr.

Running time (hr.)	Product analyses (%) UF_4	UO_2	UO_2F_2
1.5	96.5	2.4	0.29
3	95.7	2.6	0.34
4.5	96.5	2.5	0.31
6	93.4	4.5	0.30
7.5	94.8	3.5	0.24
9	94.6	3.9	0.22
10.5	93.7	4.8	0.24
12	91.9	6.7	0.14
13.5	93.5	5.3	0.16

mine the approximate operating conditions, particularly with regard to the optimum bed temperatures for reduction and hydrofluorination. This was done in a series of batch, fluidized runs. Following this work, a number of continuous runs were made with single and multistage fluidized beds.

PHYSICAL PROPERTIES OF THE URANIUM OXIDE

The uranium trioxide, uranium dioxide, and uranium tetrafluoride were fluidized in glass equipment in order that fluidization characteristics and the proper gas velocities might be determined. A typical starting bed particle-size distribution is shown in Table 1. It was found later that little change in particle size occurred during the various process steps except for the production of a small amount of fines by attrition. The bulk density of these uranium compounds ranged from 3.0 to 4.2 g./cc., the tetrafluoride having the lowest density. Gas velocities above 0.3 ft./sec. were found to produce satisfactory fluidization, and for the work reported here velocities were limited to the range of 0.3 to 0.6 ft./sec.

BATCH EXPERIMENTS—Single-Stage

To determine the effect of temperature on the reduction reaction, batch single-stage runs were made at three different temperatures, the results of which are summarized in Table 2. Uranium trioxide was fluidized with a mixture of approximately equal volumes of hydrogen and nitrogen for a period of 4 hr. at the indicated temperatures. As expected, the highest percentage conversion was obtained at the highest temperature (700° C.); however, satisfactory conversion was also attained at 575° C., and for reasons which will be discussed the latter temperature was selected for subsequent experiments.

A study of the hydrofluorination reaction revealed that the rate at which uranium dioxide reacted to produce uranium tetrafluoride was dependent upon the temperature used in preparing the dioxide. In Table 3 are shown the results of a series of batch, fluidized, hydrofluorination runs with uranium dioxide prepared at various temperatures.

Temperature Effects in Reactions

The data in Table 3 show that the rate of hydrofluorination is very slow with uranium dioxide produced at a high reduction temperature (700° C.), resulting in only 66% conversion after 4-hr. hydrofluorination. On the other hand, at least 95% conversion was obtained under similar hydrofluorination conditions with uranium dioxide produced at a reduction temperature of 575° C. or less. A positive explanation for the effect of high reduction temperature has not yet been found, although it is believed the decrease in reactivity could be due to the relief of crystal strains induced in the uranium trioxide during its production from uranyl nitrate.

To complete the preliminary investigation of temperature effects in these reactions, additional batch runs were made at various hydrofluorination temperatures from 390 to 575° C. as shown in the Table 4.

Best results were obtained at the highest temperature studied (575° C.), and it is possible that higher temperatures would give even greater conversion; however, high temperatures are optimum only when the hydrogen fluoride concentration is high relative to the moisture content of the gas phase, as it was in these batch runs. In the presence of appreciable moisture, such as would exist in the gas phase at the gas exit end of countercurrent equipment, it is necessary to use lower temperatures in order to minimize the reverse reaction.

CONTINUOUS OPERATION—Single Stage

Continuous production of green salt by the fluidized-bed technique was first demonstrated in a single-stage reactor. A typical reduction run is summarized in Table 5. Uranium trioxide was fed continuously at 3.2 lb./hr. into a fluidized bed consisting of approximately 17 lb. of uranium oxide maintained at a temperature of 575° C. The average residence time of the solids in the reactor thus was about 5 hr. A mixture of hydrogen and nitrogen at a mole ratio of 2.8 to 1 was used as the fluid-

Fig. 1. Flow diagram for processing uranium ore concentrates or spent nuclear fuels.

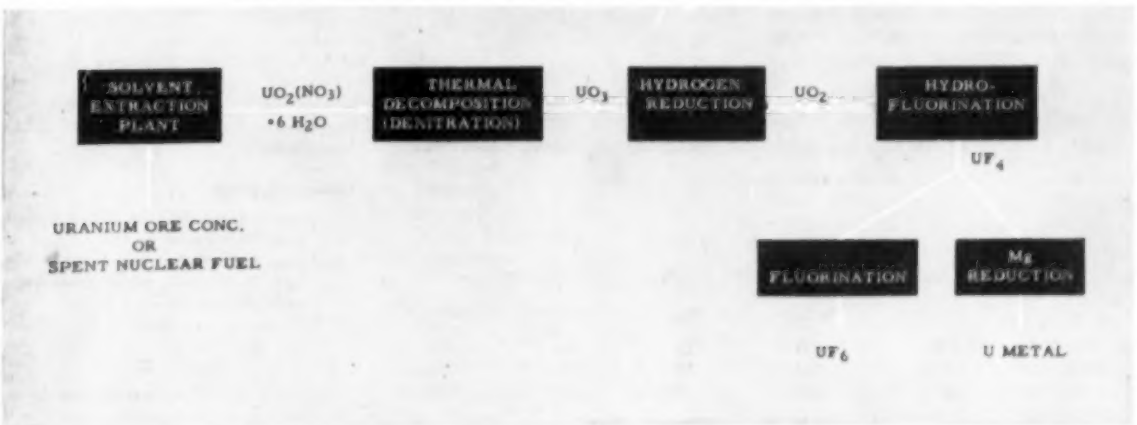

Table 7.—Comparison of Single and Multistage Hydrofluorination Runs

Reactor type	Hydrofluorination temp. (° C.)	Average solids residence time (hr.)	Percentage unconverted UO_2
Single stage	450	16	1.4
Multistage	450 each stage	8	1.8
Multistage	400 to 600, top to bottom	4	0.9

izing gas at a superficial velocity of 0.4 ft./sec. Product was withdrawn from the bottom of the bed at a rate corresponding to the feed, and samples of the product were analyzed at 1½-hr. intervals. The results show that 95 to 96% conversion of uranium dioxide was achieved under these conditions.

A typical single-stage hydrofluorination run is summarized in Table 6. Uranium dioxide was continuously fed into a bed of uranium tetrafluoride fluidized with hydrogen fluoride gas at 0.47 ft./sec. The bed temperature was maintained at 450° C., and the average residence time of the solids in the bed was 8.5 hr. Samples of the product were analyzed at intervals of 1½ hr. Results show that the product was approximately 93% converted to uranium tetrafluoride. This degree of conversion is suitable for uranium tetrafluoride intended for subsequent conversion to uranium hexafluoride, but is not suitable for reduction to uranium metal.

To demonstrate that more adequate conversion could be achieved by additional exposure of the solids to hydrogen fluoride in a second stage, the product from the run shown in Table 6 was again fed through the reactor under the same operating conditions. This treatment reduced the unconverted oxide content to 1.4%, a value considered satisfactory for metal production.

CONTINUOUS OPERATION—Multistage

For satisfactory operation of the small-scale multistage reactor, it was found that the gas-distributor plates and downcomers required careful design. The pressure drop across the gas distributor plate had to be sufficiently high that uniform gas distribution might be obtained, but not so high as to require excessively long downcomers to balance the pressure drop. Since some "slugging" occurred in the downcomers, extra length above that necessary to balance the pressure drop was required to preclude cycling of solids up the downcomers. To minimize "slugging," the height-to-diameter ratio of the downcomers was kept as small as was practical.

Design problems of this type are magnified with small-scale equipment because of the relatively large height-to-diameter ratios needed for this size unit. The 3-in. diam. unit, however, operated satisfactorily and has served as the design basis for pilot-scale units now under construction.

Several reduction and hydrofluorination runs were made in the multistage reactor primarily to demonstrate satisfactory mechanical operability. It was found that the advantage of the multistage unit over the single-stage reactor was most apparent in the hydrofluorination step, particularly when a temperature gradient from top stage to bottom stage was used as shown in Table 7.

Under equivalent temperature conditions only one half as much residence time for the solids was required in the three-stage unit as in the one-stage unit. With improved temperature conditions, that is a gradient from 400° C. on top to 600° C. on the bottom stage, the required solids residence time was again reduced by one half.

The effect of the temperature gradient is further illustrated in Table 8, which shows the results of additional runs made under various temperature conditions. Experience in the fluidized-bed reactor as well as in the production-scale reactors indicated that a low initial reaction temperature is necessary to avoid loss of reactivity which can result from partial sintering of the solids when there is too rapid initial reaction. However, for conversion of the last 5 to 10% of the oxide in the green salt particles, a higher temperature yields more rapid reaction. Thus, as shown in Table 8, the residual unconverted oxide in the green salt product was only one tenth as great when a graduated temperature of 400° C. on the top stage to 600° C. on the bottom stage was used, as when a uniform temperature of 450° C. was used on all three stages.

Table 8.—Effect of Temperature Gradient in Multistage Hydrofluorination Runs

Average solids residence time—4 hr.
Gas velocity—0.5 ft./sec.
Gas composition—60% HF, 40% N_2
Solids feed rate—2.0 lb./hr.

Stage temperatures (° C.)			Percentage unconverted oxide		
top	middle	bottom	top	middle	bottom
450	450	450	21	8.9	7.0
400	475	550	28	9.4	2.5
400	500	600	17	1.6	0.7

Conclusions

The use of single-stage and multistage fluidized-bed reactors for the conversion of uranium trioxide to uranium tetrafluoride has been demonstrated on a bench-scale. The multistage reactor has been found to be considerably more efficient than the single-stage reactor, particularly in the hydrofluorination step. Equivalent results could, however, be achieved by the use of several single-stage reactors in series, probably, however, at a higher capital cost.

From a mechanical standpoint, the continuous operation of the 3-in. diam., multistage reactor was satisfactory. In order to determine the practicality of scale-up of this design, a pilot-scale facility consisting of a 4-stage, 5-in. diam. reduction reactor and a 5-stage, 6-in. diam. hydrofluorination reactor is under construction.

Acknowledgment

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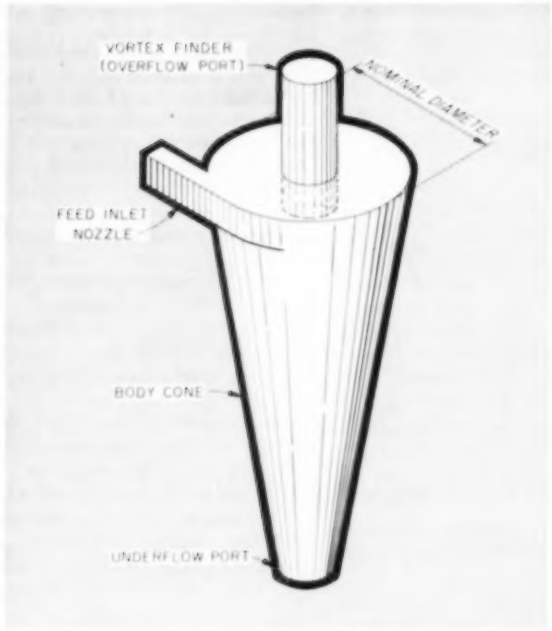

Fig. 1. Typical hydroclone.

MIDGET HYDROCLONES REMOVE MICRON PARTICLES

P. A. Haas, E. O. Nurmi, M. E. Whatley, and J. R. Engel | Union Carbide Nuclear Company,* Oak Ridge, Tennessee

From the nuclear program come dimensional and flow capacity correlations reported from operation of hydroclones of less than one inch diameter with particles as small as one micron in aqueous solutions.

Use of hydraulic cyclones, or hydroclones, in removing 1-μ solid particles from aqueous solutions was developed in order to supply a simple, durable, liquid-solid separation apparatus to remove precipitated fission and corrosion products from uranyl sulfate solutions employed in aqueous homogeneous reactors. Removal of such particles required hydroclones of less than 1-in. diam., and experiments were limited to 0.16, 0.25, 0.40, and 0.50-in. diam. units. Results were intended to permit selection of both optimum hydroclone units and optimum operating procedures for the proposed reactor applications.

The use of liquid-solid separators was suggested by the low solubility of some fission products in uranyl sulfate solutions (*1*). Solubilities of many contaminants of reactor fluid streams are in the range 3 to 50 p.p.m. at 250 to 300° C. These include iron oxides and ZrO_2 in water and iron oxides, ZrO_2, rare earth sulfates, and some other fission products in uranyl sulfate solutions. Complete removal of the insoluble and the gaseous fission products would represent removal of >80% of the fission product poisons. Thus, a combination of liquid-solid separation and gas-removal methods could reduce, and perhaps completely replace, other methods of processing aqueous solution fuels. Removal of insoluble corrosion products from aqueous coolants is another possible application of hydroclones to reactor systems.

In a hydroclone, the centrifugal field caused by the high velocity of fluid entering on a tangent results in accumulation of the heavy phase at the walls. This can be withdrawn as an underflow stream. The feed port of a hydroclone is at the point of largest diameter (Figure 1); this diameter is used to identify the hydroclone size. The vortex finder, extending down into the hydroclone cavity, contains the overflow port. The hydroclone body tapers to the underflow port. Experimental work reported by several investigators (*2, 3, 5*) has determined the hydroclone flow patterns (Figure 2). The fluid entering takes spiral paths downward. As the fluid moves toward the hydroclone center, at some point the vertical velocity reverses to a spiral path to the overflow

* Unit Operations Section, Chemical Technology Division.

Table 1.—Hydroclone Efficiencies

Material: thorium oxide in water at room temperature; 80 wt. % of ThO_2 between 0.6 and 3.0-μ diam.

$P_f - P_o$: pressure drop through hydroclone from feed inlet to overflow exit.

Percentage underflow ratio: $B/F = \frac{\text{volume of underflow}}{\text{volume of feed}} (100)$

Hydroclone dimensions		Feed conditions		Percentage underflow ratio,	Hydroclone efficiency,
D_c (in.) diam.	length, L (in.)	$P_f - P_o$ (lb./sq.in.)	flow rate (gal./min.)	B/F in %	E_1 (%)
0.25	1.50	25	0.15	6	27
		49	0.20	6	36
		136	0.30	6	57
		251	0.40	6	67
0.25	1.50	35	0.22	6	42
		35	0.21	6	43
0.40	3.14	35	0.72	6	37, 34, 40
		35	0.77	6	43
		44	0.87	9	37
0.40	2.40	44	0.76	10	39, 44, 42

port. A particle which is to be removed in the underflow stream must be accelerated by the centrifugal force to a velocity which keeps it out of the inner spiral to the overflow. Boundary flows can exist, and such a flow at the top can result in a short circuit of fluid with little phase separation.

Advantages of Hydroclones

The major advantages of the liquid cyclone or hydroclone are simplicity, small size, high efficiency, and high capacity. It can be easily designed to handle high-temperature and high-pressure fluid streams. Almost any material which will withstand the fluid processed can be used as the material of construction. The energy required for the separation process is obtained as a fluid pressure drop and can be supplied by a pump. Compared to a centrifuge or continuous filter, a hydroclone has no moving parts and no mechanical seals. The concentrated solids leave as a slurry stream. A hydroclone avoids nearly all the difficult remote maintenance or cleaning problems associated with the use of centrifuges or filters on radioactive materials.

Hydroclone Dimensions

Studies were made to permit dimensioning of hydroclones to separate particles of 1- to 10-μ size, since precipitated rare earth sulfates and corrosion products in homogeneous reactor fuel were expected to be in this size range. Experimental work was limited to hydroclones between 0.16 and 0.50-in. diam. Hydroclone efficiency comparisons were made by using a ThO_2 slurry in H_2O. Efficiencies for material containing 80 wt. % particles between 0.6 and 3.0-μ diam. ranged from 20 to 70%. The first four columns of Table 1 show the effects of the feed-to-overflow pressure drop. The remaining columns are for half a dozen different hydroclone units and show the reproducibility of results.

DIAMETER EFFICIENCY CORRELATIONS

Constants were calculated for efficiency correlations developed from Stokes' law and from experimental studies reported in the literature (*1, 5*). The diameter particles removed with 50% efficiency, d_{50}, can be shown to be proportional to $(D_c)^{1/2}$ and to $(\Delta P)^{-1/4}$. The following equation is suggested for rough estimates of the performance of hydroclones of less than 1-in. diam. and with the optimum dimension ratios determined (see Table 2):

Table 3.—Values of *K* for Hydroclones

Hydroclone diameter (in.)	K (ft. of liquid)(in.)^4 / (gal./min.)^2	K' (ft. of liquid)(in.)$^{4.1}$ / (gal./min.)$^{2.21}$
0.16	0.060	0.070
0.25	0.062	0.076
0.40	0.07	0.058
3.0 to 6.0[a]	0.15	0.07
3.0[b]	0.15	0.079

[a] Reported by Yoshioka and Hotta (*5*).

[b] Calculated from values reported by Kelsall (*2*).

$$d_{50} = 5 \times 10^3 \frac{D_c^{0.5} \mu^{0.5}}{\Delta l^{*0.25} (\rho_s - \rho_l)^{0.5}} \quad (1)$$

where

d_{50} is the diameter of particles removed with 50% efficiency, μ

D_c is the hydroclone I.D., in.

μ is liquid viscosity, lb./(ft.)(sec.)

Δl^* is the feed-to-overflow pressure drop, ft. of liquid

ρ_s is the solid phase density, lb./cu.ft.

ρ_l is the liquid phase density, lb./cu.ft.

The particle diameter, viscosity, and density terms are fixed by the system to be processed. The hydroclone diameter and the pressure drop can be varied to obtain the necessary hydroclone efficiencies.

Table 2.—Hydroclone Dimensions

Basis: studies on hydroclones of less than 1-in. diam.; values are consistent with literature values for 3- to 6-in. diam. hydroclones.

Symbol	Dimension Nomenclature	Suggested dimensions as fraction of D_c dimension	Combination [b] for use with an underflow pot
D_c	hydroclone I.D. at feed port	1	1
L	hydroclone inside length	5-8	6
D_f [a]	feed port diam.	1/3-1/7	1/4
D_u	underflow port diam.	1/3-1/6	1/4
D_o	overflow port diam. vortex finder I.D.	1/4-1/6	1/5
OD_o	vortex finder O.D., extension into hydroclone	1/3-1/6	1/4
L_o	vortex finder length, extension into hydroclone	1/3-1/2	3/8

[a] Use of a rectangular feed port is usually desirable. The port area then may be made equivalent to circular ports of the diameters suggested.

[b] These dimensions have been used and are suggested for operation with batch underflow accumulation in an induced underflow pot.

DETERMINATION OF OPTIMUM DIMENSIONS

Optimum hydroclone dimensions for 0.25 and 0.40-in. diam. units were determined with ThO_2 slurries. These optimum dimensions were expressed as ratios of a primary dimension, that is, the inside diameter of the hydroclone at the feed port, D_c (Table 2). These optimum dimension ratios were based on the efficiencies for pressure drops of 80 ft. of liquid. Since these ratios agree with literature values for larger hydroclones, they probably apply to a wide range of sizes. The hydroclone length, L, feed port diameter, D_f, and overflow port diameter, D_o, showed distinct efficiency maximums. The length and the underflow port diameter determine an induced underflow ratio to be discussed (Figure 4). Use of a cylindrical section at the point of feed introduction showed no detectable advantages and was omitted to simplify hydroclone construction.

FLOW CAPACITY CORRELATION

From theoretical consideration of dimensionally similar hydroclones, the flow is proportional to the square root of the feed-to-overflow pressure difference and to the square of the hydroclone diameter. A more generalized correlation has been developed by Yoshioka and Hotta (5):

$$\Delta P = \frac{KQ^2}{D_c^{0.9} D_f^{1.2} D_o^{1.9}}$$

where

ΔP is the feed-to-overflow pressure difference
Q is the volume feed rate
D_c is the hydroclone inside diameter
D_f is the equivalent feed port diameter, that is, the diameter of a circular port of equal area
D_o is the overflow port inside diameter
K is a constant for a selected set of units

The value of K would actually be determined by the fluid system and the surface finish, and perhaps by other hydroclone dimensions. Some values of K were determined experimentally or from literature data for feed flow in gallons per minute, diameters in inches, and pressure differences in feet of liquid (Table 3). The values of K apply for 80% or more of the feed volume leaving through the overflow port. From Equation (2), log ΔP vs. log Q should give a straight line with a slope of 2.00. The observed slopes for more than thirty hydroclones of 0.16, 0.25, and 0.40 in. diam. ranged from 2.10 to 2.45 with an average value of 2.27. Similar results have been previously reported (2, 3) for larger hydraulic cyclones. Revision of the correlation to give Equation (2a) gives much less variation in the value of the new constant, K' (Table 3).

$$\Delta P = \frac{K'Q^{2.27}}{D_c^{0.8} D_f^{1.2} D_o^{2.0}} \qquad (2a)$$

Poor design and construction details such as burrs or nontangent inlet ports result in lower values of K. This would be expected if these faults resulted in smaller centrifugal fields. When a hydroclone is designed with the dimension ratios previously suggested as being optimum (Table 2), the diameter terms in Equation (2a) can be combined into one variable. The equation for hydroclones of less than 1-in. diam. then becomes

$$Q = 0.37(\Delta P)^{0.44} D_c^{1.8} \qquad (3)$$

Batch Underflow Accumulation

Accumulation of the heavy phase in an underflow receiver, a cavity into which the hydroclone underflow port opens (Figure 3), was found to be a useful alternate method of hydroclone operation. The concentrated heavy phase flows through the underflow port along the hydroclone walls. An equal volume of pot solution returns through the center region of the underflow port. This type of operation resembles that of dust collection in a gas-solid cyclone separator. Settling out in the underflow pot could increase the effectiveness of a hydroclone operated in this way. However, precipitated fission products collected by a hydroclone might not settle out because of their small particle size and the presence of thermal convection currents from radiation heating.

This batch underflow accumulation eliminated an otherwise difficult flow-control problem. With a continuous underflow, obtaining high concentration factors requires a small volume underflow rate. Metering this slurry stream would be difficult, especially if the slurry was to be let down from >100 to 1 atm. pressure, as would be the case in several proposed aqueous system homogeneous reactors. The batch underflow accumulation permits isolation of the hydroclone and pot with batch letdown of the complete hydroclone and pot volume without disturbance of reactor operation.

The ratio of the volume flows of the induced underflow and the hydroclone feed is determined by the geometry and in turn helps determine the equilibrium concentration factor. Induced underflows of 0 to 4% by volume of the feed flow were possible without large changes in hydroclone efficiency.

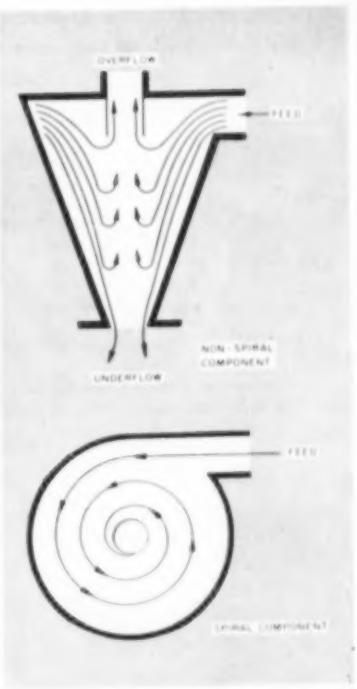

Fig. 2. Hydroclone flow patterns.

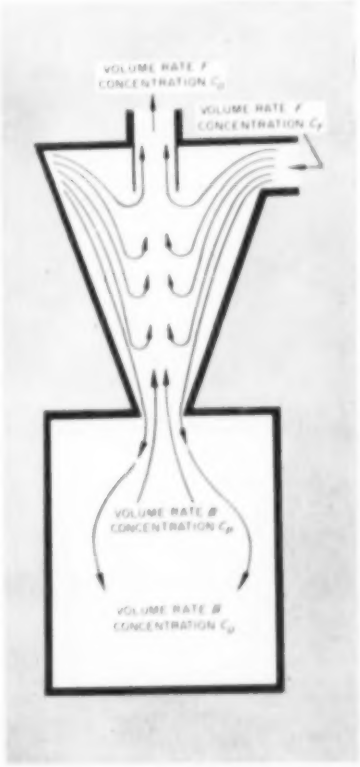

Fig. 3. A hydroclone and underflow pot.

Table 4.—Experimental Concentration Factors for Underflow Pot Operation

Hydroclone diam. (in.)	Material	Material Size 50% ≤ d ≤ 50% (μ)	Distribution wt. %	Distribution range (μ)	Observed concentration factor C pot/C feed
0.25	ThO_2	4.1	70	3.0 to 7.1	2,300
		4.1	70	3.0 to 7.1	2,420
		1.8	71	0.8 to 4.2	78
		1.8	71	0.8 to 4.2	93
	ZrO_2	1.0	80	0 to 4.0	4,500
0.40	Fe_2O_3 [a]	0.5	80	0.2 to 0.5	270[b]

[a] Observed concentration factor and particle-size measurements were for different samples of Fe_2O_3.

[b] This concentration factor is based on the total iron in the hydroclone feed and would be higher if it were based on insoluble iron only.

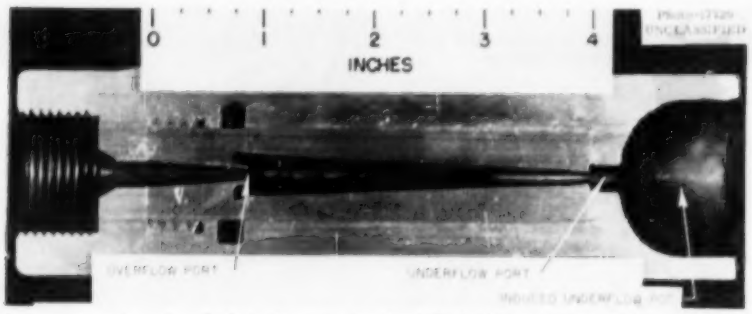

Fig. 4. Corrosion of a 0.40-in. diam. titanium-lined hydroclone. Length: 3.14 in. Material: titanium 55A. Conditions: 10-300 g. of U/kg. H_2O, 250-300° C. Test period: 1,356 hr. Feed flow: 1.0 gal./min.

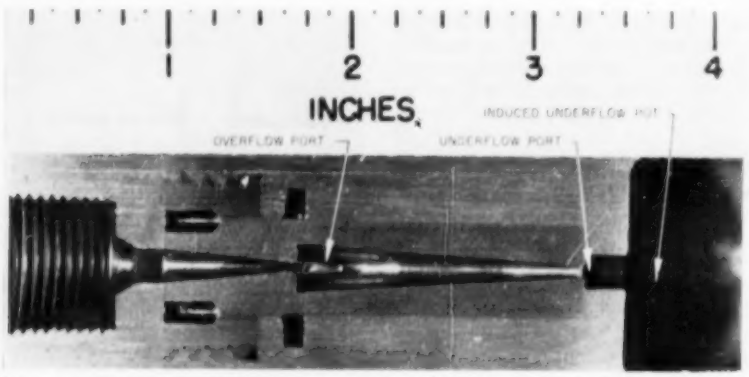

Fig. 5. Corrosion of a 0.25-in. diam. titanium-lined hydroclone. Length: 1.50 in. Material: titanium 55A. Conditions: 10 g. of U/kg. H_2O, 300° C. Test period: 3,975 hr. Feed flow: 0.23 gal./min.

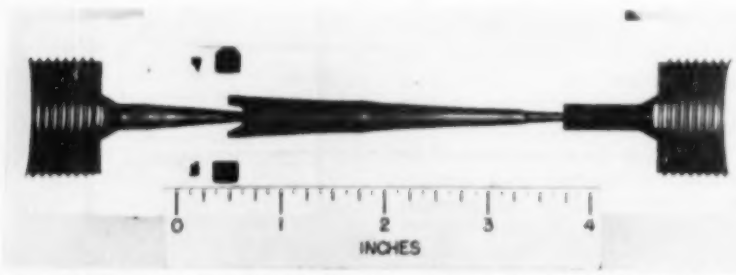

Fig. 6. Corrosion-erosion of a 0.40-in. diam. 347 stainless steel hydroclone. Length: 3.14 in. Conditions: 15 g. of U/kg. H_2O, 250° C. Test period: 200 hr. Feed flow: 0.6 gal./min. Remarks: ¾-in. depth plug of solids above underflow port.

The hydroclone dimension ratios suggested (Table 2) give induced underflow ratios of about 1.5%. A material balance can be arranged to give an expression for the equilibrium concentration factor. This concentration factor is the concentration of material returning to the hydroclone from the underflow pot over that of the feed stream. At equilibrium, the feed and overflow concentrations will be equal. The concentration factor, CF, may be calculated from the relation

$$CF = \frac{F}{B} \cdot \frac{E_1}{1 - E_2}$$

where

F/B is the feed to underflow volume flow ratio

E_1 is the hydroclone efficiency for removal of heavy phase from the feed stream

E_2 is the hydroclone efficiency for returning to the pot any heavy phase in the volume displaced from the pot.

Since E_2 approaches unity for materials for which E_1 is reasonably large (>30%), the possible concentration factor may be of the order of 10^3 or 10^4. Concentration factors of up to 4,500 have been obtained experimentally (Table 4). The efficiencies for precipitated iron oxides have consistently been higher than could be predicted from microphotographs of particle sizes. This may be due to particle agglomeration.

Operating Problems

CORROSION

Acceptable materials of construction for hydroclones to be used at 250° C. would be type 316 stainless steel for water and titanium for uranyl sulfate solutions. Titanium hydroclones have been corroded at rates of less than 10 mils/yr. by uranyl sulfate solutions containing 10 to 400 g. U/kg. of H_2O at 250 to 300° C. (Figures 4 and 5). It is believed that titanium hydroclones will withstand uranyl sulfate of any concentrations now proposed for aqueous homogeneous reactors. Stainless steel hydroclones tested with uranyl sulfate solutions containing 10 to 15 g. U/kg. H_2O at 250 to 320° C. have shown corrosion rates from less than 10 to more than 100 mils/yr. This range in rates is probably due to minor variations in conditions since stainless steels have critical velocities which separate regions of high and low corrosion. Velocities at the hydroclone port or wall are of the order of 20 ft./sec. Stainless steel hydroclones are considered undependable

for uranyl sulfate solutions although they are probably adequate for coolant water streams.

OPERATING FLEXIBILITY

In commercial applications hydroclones have been set in parallel to increase capacities and in series to increase the concentration factors. Such usage would also be possible with reactor systems. In batch-accumulation operation, parallel units might be able to use one common underflow pot. This type of operation will be tested to determine if corrosion or solids accumulation can result in zero underflow and thus zero efficiency for one of the parallel units.

No plugging of feed or overflow ports was observed during application of hydroclones to a variety of precipitated corrosion and fission products in high-temperature high-pressure systems. The port sizes were of the order of 0.05- to 0.10-in. diam. The possibility of plugging could be minimized by use of a coarse screen or scalping hydroclones to catch particles larger than the hydroclone port diameter. The underflow ports did not become plugged in induced underflow operation. When the underflow was temporarily interrupted in hydroclones designed for continuous underflow takeoff, the plugs of solids which accumulated in the underflow line or port were difficult to remove and hydroclone erosion (Figure 6) resulted.

A design was developed to permit replacement of a hydroclone in a radioactive system by use of a flanged closure and remote tools (Figure 7). All connections and the underflow receiver are attached to the lower flange. The flange bolts, the hydroclone retainer, and the hydroclone could be removed and replaced by remote tools. Replacement might be necessitated by a corroded or plugged hydroclone, or by the need for a different capacity, underflow ratio, or efficiency.

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4. McNees, R. A., 2nd annual meeting, American Nuclear Society, 1st Paper, Session XIII (June 7, 1956).
5. Yoshioka, N., and Y. Hotta, *Chem. Eng. (Japan)*, **19** (12), p. 632-640 (1955).

Presented at the 2nd Annual Meeting of the American Nuclear Society, June 7, 1956, Chicago, Illinois.

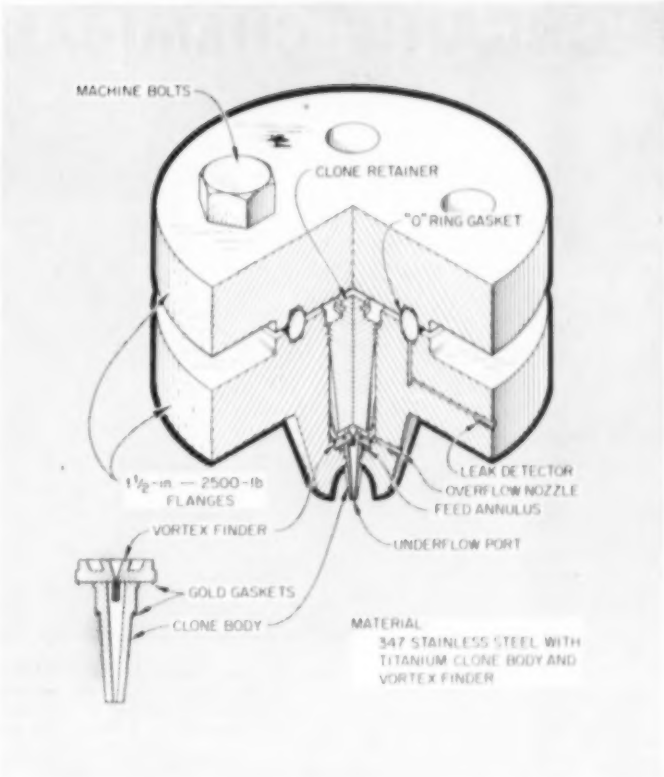


Fig. 7. Cross section of integrally flanged hydroclone

Pilot Plant Generation of Fission Products

In the article "Pilot Plant Generation of Fission Products in Uranium-Bismuth Reactor Fuel" by C. J. Rasemann, H. Susskind, and C. H. Waide, *CEP*, February, 1957, Figure 6 on page 91-F is incorrect, and the correct Figure is reproduced herewith (right). Also, the ordinate, k_w, should appear on Figure 7. On page 90-F of this article, column 1, line 5, the figure 0.073 should read 0.3.

Roasting to Remove Fluorides

In the article "Roasting to Remove Fluorides from Ammonium Diuranate" by E. R. Johnson, E. O. Rutenkroger, H. M. Beers, and A. B. Kreuzmann, *CEP*, November, 1956, Figure 4 on page 475 should be interchanged with Figure 5 on page 476.

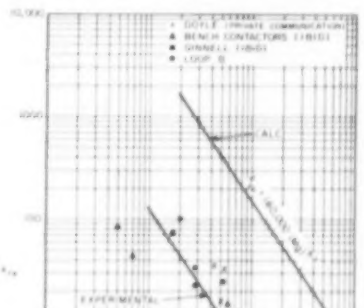


Fig. 6. Distribution of Ce^{144} between bismuth and salt ($MgCl_2$—NaCl—KCl) at 500° C.

A report from the White Sulphur Meeting

raw materials future for INORGANIC CHEMICALS

I. H. Munro | Solvay Process Division
Allied Chemical & Dye Corporation
New York, New York

The time has arrived when our best minds must go to work seeking economical and effective ways of using lower grade raw materials or even materials of an entirely different character for our inorganic chemical industry.

The heavy chemicals industry is especially sensitive to the quality, quantity and availability of natural resources. Requirements are measured not by the pound but by the ton—thousands of tons each day. It operates on two important premises; first that the necessary raw materials be available in virtually unlimited tonnages; second, that this industrial sustenance be located near producing plants. Any serious disruption of these basic supplies, or any drastic price increase, could well be a matter of life or death for certain operating units within the industry.

Even a plentiful supply of raw materials does not always justify complacency among manufacturers of basic chemicals. Take sodium chloride, for example. This vital mineral occurs in unlimited quantities over widely scattered areas of the United States. The ocean itself provides an inexhaustible supply of salt, providing it can be recovered at tolerable costs. It would seem that there should be virtually no difficulty in insuring a supply for the indefinite future. Actually, however, serious problems are arising in assuring salt supplies to existing producing centers as well as in supplying sodium chemicals to new population centers and markets.

Site versus Supply

At existing plant locations, salt supplies are becoming a problem, either because past mining practices have taken the easily available material and have thereby made remaining reserves inaccessible, or because original deposits are becoming exhausted. How, then, can a plant at a specific location continue to obtain its supply of salt at low cost? Some of our best geological, chemical and engineering minds are seeking the answer. New techniques of brine well construction and operation are being developed and extensive use has been made of procedures and techniques developed in the oil industry which allow deeper solution mining and more effective removal of salt deposits. In addition, present need has sparked a search for new salt deposits, for more effective means of recovering sodium chloride from mixed salts in some of the dry lakes in the Far West and for ways of increasing solar salt supply from the oceans.

Process to the Rescue

Aluminum is one of the most abundant elements in the earth's crust. However, the available supply of high purity bauxite in the United States is extremely limited. The very rapid growth of the aluminum industry soon exhausted the high purity material, and it became necessary to look to other sources, principally in the Caribbean area, for an adequate supply. It has been predicted that, at the estimated rate of growth of the industry, present known bauxite reserves of the Western Hemisphere will be about two-thirds consumed by 1975. Of course, there is always the possibility that known reserves will be augmented by further discoveries but, from the standpoint of national security, the raw material supply situation is far from comfortable.

For a report on Raw Materials Futures for Organic Chemicals, see article by H. A. Mitchell and R. L. Kittle of Shell Chemical Co. in March *CEP*, page 86.

The industry has carried out extensive research on the development of processes which can use lower quality ores without severe economic penalty. Process improvements resulting from this research have now made it almost as economical to use high-silica bauxite ore as the low-silica ores formerly considered standard. Furthermore, processes are under development looking to the use of alumina-bearing clays, which are available in almost unlimited quantity.

Here is an example of the application of technical skill and research ingenuity in the development of manufacturing processes which overcome a natural shortage of high purity raw materials and still hold manufacturing costs within a reasonable range.

Recovery Plus Pollution Abatement

Another basic raw material essential to our heavy chemical production is sulfur. For many years the principal domestic source of sulfur has been the salt dome areas. Sulfur has been recovered by the low-cost Frasch process, in which the sulfur is melted underground by a stream of hot water and pumped to the surface in pure form.

All will remember the crisis which developed only a few years ago when the available quantity of Frasch sulfur was inadequate to meet the rapidly growing demand. This situation has apparently been at least temporarily relieved by the discovery of additional deposits of sulfur both in this country and in adjacent areas such as Mexico. Here again, however, there is the constant threat that new discoveries will not keep up with increased demand. Years of study and development have perfected methods by which sulfur (or sulfur dioxide) can be recovered from other sources at reasonable costs.

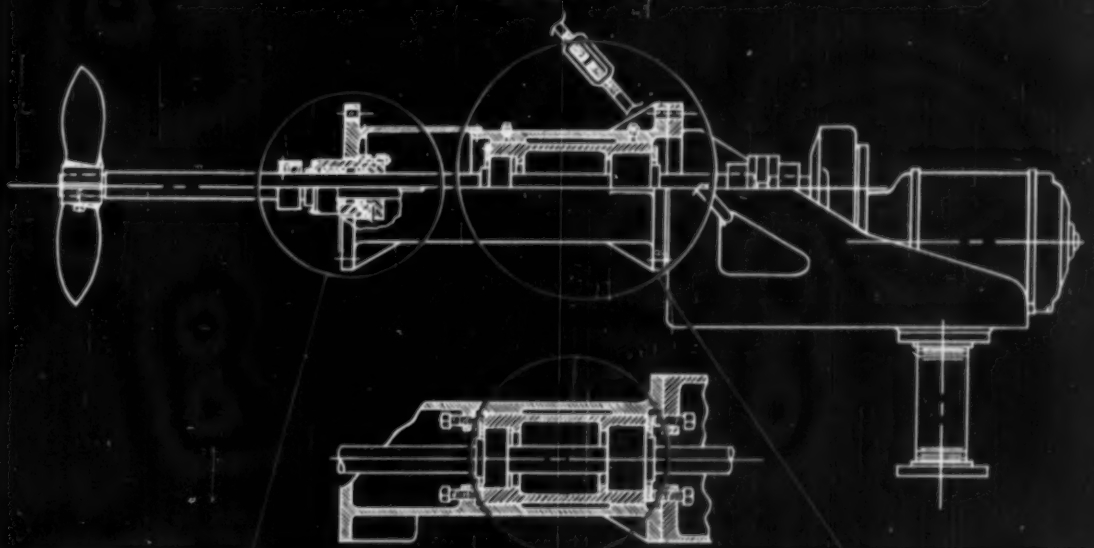
Vast quantities of sulfur are available in the form of pyrites, pyrrhotite, and gypsum or anhydrite. Manufacture of sulfuric acid from pyrites and pyrrhotite is a well established commercial operation in the United States, and processes based on gypsum have been utilized in other countries. Further, processes have been worked out to utilize waste sulfur-bearing gases; in this case, abatement of pollution problems has been an additional spur. Here again, chemical technology has learned how to supply industry with the necessary raw materials after the cream has been skimmed off the bottle.

Industrial Water Crisis

It has been estimated that U. S. industry uses almost 50 times as much water by weight as all other industrial materials. Water requirements for industrial uses are rising steadily,

(*Continued on page* 56)

announcing the new TURBO-MIXER side entering propeller series



Repeckable Stuffing Box: standard in the sizes from 10 H. P. up, and obtainable in all sizes from 1 H. P., utilizing a special Turbo-designed positive seal mechanism.

Simplicity: only 2 bolts to turn to retract the bearing housing and apply the positive pressure to the sealing device, and only 2 bolts to turn and to return it to operating position. The gear-motor doesn't move an inch!

Retracting Bearing Housing: no pulling the shaft back through a bearing (which means a loose shaft-to-bearing fit). In the Turbo, the complete housing retracts, leaving the bearings untouched, in perfect shop-fitted alignment, keeps them that way.

Expertly designed, based on 44 years of specialized experience. The simple, sturdy design of this new series of Turbo-Mixers makes servicing easier, reduces maintenance costs. Models are available in standard sizes from 1 H. P. to 30 H. P. in two series, AD (direct drive) or AV (V-belt). All are available with a special mechanical seal which can be replaced while the tank is full.

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Please send me the following Turbo-Mixer Bulletin(s):

_____Side Entering Propeller Mixer Bulletin

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_____Minerals Processing Bulletin

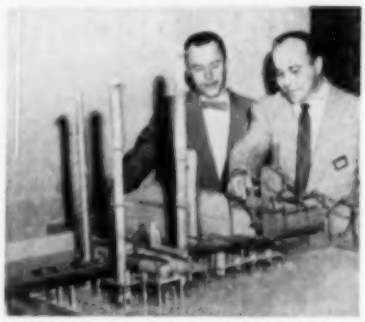
_____General Turbo-Mixer Bulletin

NEW CALLERY PLANT WILL BE MAJOR PRODUCER OF HIGH-ENERGY BORON FUELS

The ready-to-be-constructed Callery Chemical-U. S. Navy Dept. plant at Muskogee, Okla., will be country's first major plant for the production of the new, highly important boron compound high-energy jet fuel.

Ground has been broken for Callery Chemical's new $38 million plant which will not only be the largest in this country, but the largest in the world to produce the new, vital high-energy boron compound fuel. Some construction is already under way, major chemical processing units will go into construction late this summer with the target date for full operation set for the end of 1958. Initial production facilities will occupy only a portion of the 1,300 acre site, leaving the balance for future expansion.

Characteristics of the new fuel are still a military secret, but the Navy has revealed that gallon for gallon the fuel, known as HiCal, will multiply the range of a jet plane or missile and permit flying at altitudes substantially higher than any aircraft can reach today without rocket power.



Artist's layout of the new high-energy boron compound fuel plant. In circle is chemical process unit shown in scale model above being studied by Callery engineers C. F. Willard and J. S. Bardin.

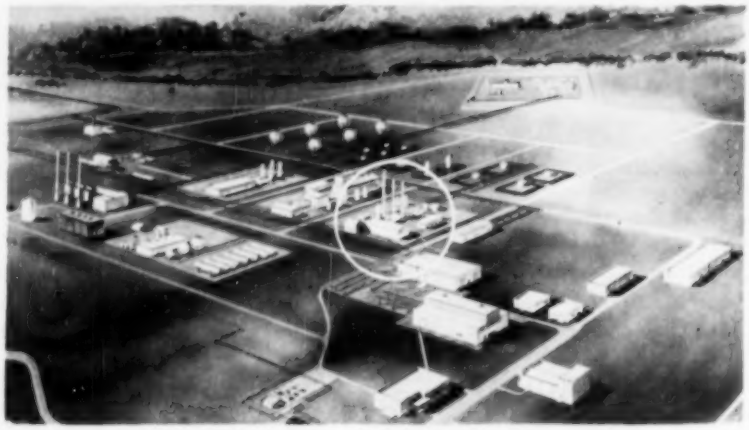
Basic Elements

HiCal is a combination of boron, carbon, and hydrogen. Hydrogen burns with a greater heat of combustion per pound than any other pure material and it was a hydrogen fuel that was sought. The principle of the fuel is that hydrogen is chemically locked in a stable liquid form and thus available as a fuel. As a boron compound the hydrogen is easy to handle and transport and can be burned with greater safety.

Boron is the most efficient carrier of hydrogen. In addition, it is light in weight and also burns. Carbon burns, too, but its primary function is as a stabilizer to permit easier and safer handling of the fuel.

By-Product

Research work on high energy fuel at Callery led to the discovery of several compounds with commercial and industrial applications. Some of the uses found for specific boron compounds are: organic reducing agents, gasoline additives, high temperature lubricants, and plasticizers. Commercial development of these chemicals is being stepped up.



FIRST COMMERCIAL INSTALLATION OF McKEE PULPING PROCESS

Cuban bagasse pulping plant will be first commercial application of the hydrotropic pulping process developed by R. H. McKee.

The plant now being built 50 kilometers west of Havana, Cuba, by the Cuban Pulp and Paper Co. is the first commercial installation utilizing the new, and in many ways unique, hydrotropic pulping process developed by chemical engineer McKee. Raw material in the plant will be bagasse, but main application of the McKee process is expected to come with U. S. hardwood pulps.

Main claimed advantages for process: high yield; no objectionable gas or effluent; easier and simpler to operate; economical (McKee claims same pulp tonnage of kraft pulp can be produced for two-thirds the cost); one-third less labor; same equipment as conventional kraft process with minor alterations; can be operated as continuous process; uses only minor amount of hard or soft water.

With these claims in mind, the U. S. pulp and paper industry is keeping a sharp watch on the future operations of Cuban Pulp's plant. Production is expected to be 125-150 tons of bleached pulp a day. Cuban Pulp has contracts with a New York firm of pulp importers for the entire production.

Bagasse Cheap, Plentiful

The other prime feature of Cuban Pulp's new plant is the utilization of bagasse as raw material. Conifer wood delivered to plants in Northern New York costs about $75 a ton of kraft pulp. Bagasse, in Cuba, is expected to cost about $15 a ton of bagasse pulp.

The company already has contracts in the U. S. for its expected by-product furfurol and lignin, expects these sales to pay manufacturing costs, leave pulp sales all pure profit.

Four Cuban sugar mills will furnish the bagasse, have taken an equity in the plant. Cuban Pulp has borrowed $4 million from the Cuban Import and Development Bank, rest of estimated $10 million capital is already privately subscribed, equipment is being bought, plant is expected to be on-stream in two years or less.

Patents

Patents on the process are held by McKee Development Corp. Four U. S. patents have been issued, four more applied for. The process is also patented in foreign countries which have suitable raw materials. Royalty for wood pulp plants would be $1.25 a ton of unbleached pulp for life of patents.

new data proves: UREA is excellent for

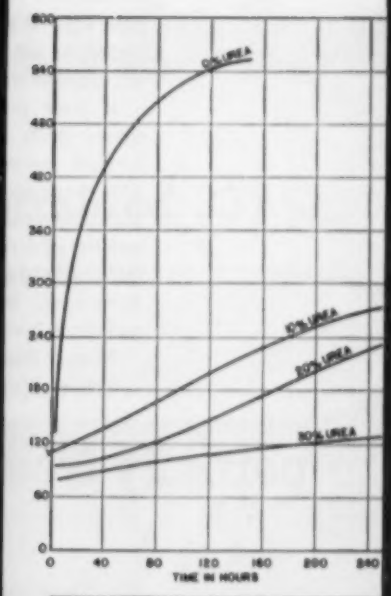
Viscosity Control

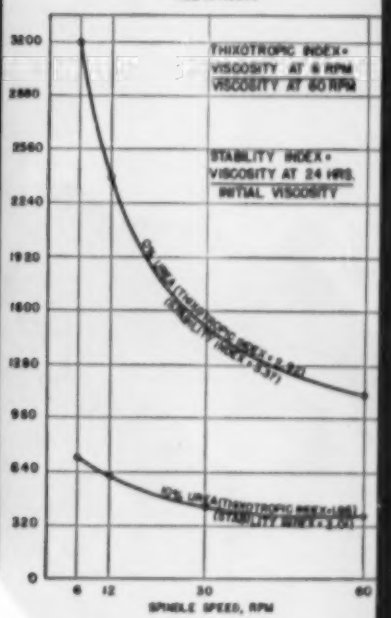
in paper coating

We can show you just how effective UREA is in controlling viscosity of modified starch, casein and Alpha Protein adhesive dispersions—and in reducing thixotropic index too.

The means: actual experimental data in the form of 15 graphs prepared by our research group, and based on field trials. Two graphs are presented on the right.

This data indicates that small amounts of UREA— • give large viscosity reductions, and drastically lower the rate of viscosity increase on standing • lower thixotropic index • permit use of adhesive dispersions with higher solids content.





Because UREA is readily available, and effective, paper coaters interested in improving operations and lowering costs will want to examine this data in detail. Send for the paper "Viscosity Control of Paper Coating Adhesives with UREA" by Belche and Ellis for the complete story.

Dept. U 2-41-1

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INDUSTRIAL NEWS

COLUMBIA-SOUTHERN BUYS INTEREST IN NRC METALS CORP.

Chemical company joins National Research Corp.'s subsidiary as NRC's zirconium plant moves forward in its construction.

Under terms by which Columbia-Southern Chemical Corp. and National Research Corp. will each contribute capital in the amount of $5 million, Columbia-Southern has acquired a 50% interest in NRC Metals Corp. Beginning when NRC's zirconium plant attains profitable operation, National will be reimbursed over a period of years for its past efforts in the zirconium and rare metals fields. Based on sales, this reimbursement is expected to aggregate $5 million. These payments will be made in addition to whatever dividends on stock are paid to the joint owners.

Major asset of Columbia-Southern to the jointly-owned company will be its chemical production and marketing experience which will be vital in the disposal of the zirconium produced and not sold to AEC. In the still-under-construction Florida zirconium plant, most, but not all, of the zirconium metal will be purchased by AEC.

Process design, engineering and construction of a 3,500 barrel per day sulfuric acid alkylation unit and feed preparation facilities for Socony Mobil Oil's Trenton, Mich., facilities, will be done by the Fluor Corp. Cost will be some $3.5 million, construction will begin this spring, completion is scheduled for early 1958. □

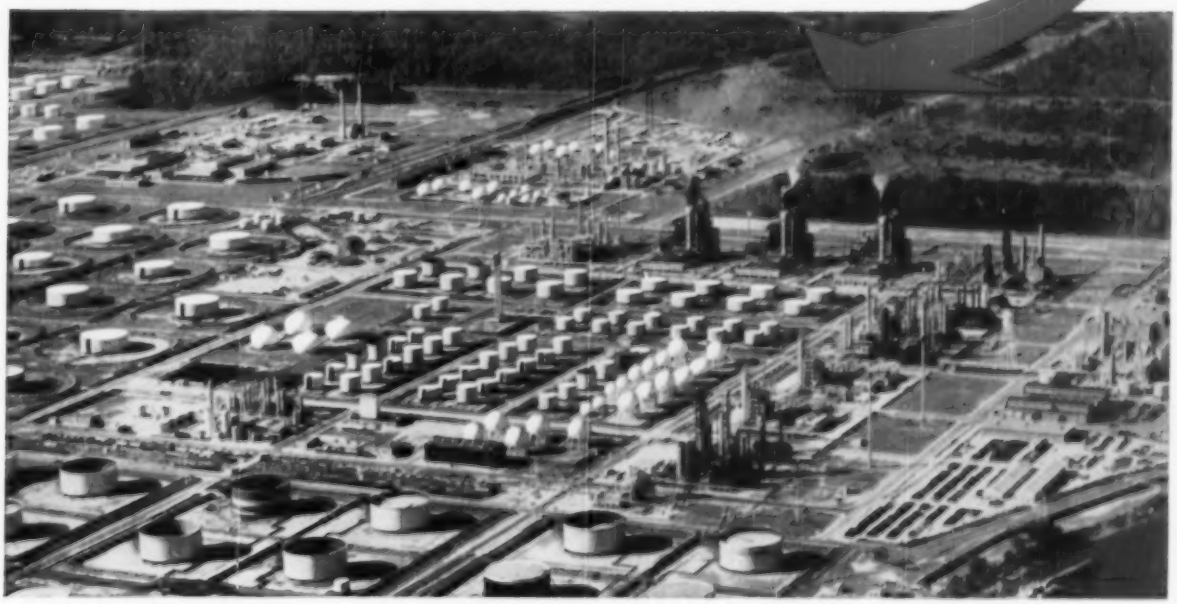
A Unifining Process Unit will be engineered and constructed by Macco Corp. for the Bakersfield, Cal., refinery of Douglas Oil Co. The Unifining Process is licensed by Universal Oil Products Co. Refinery and Chemical Division of Macco will do actual work. □

The first additional production unit for the manufacture of isocyanate chemicals at Mobay Chemical's plant at New Martinsville, W. Va. is on stream. When entire planned expansion of production facilities is completed, the over-all rate of production volume at the plant will have increased 200%. □

The first U. S. patent for a process to produce prednisone and prednisolone has been granted to Chas. Pfizer & Co. The process is a fermentation technique. □

butyl rubber

Nation's capacity will be increased 33⅓% with new PCI plant to be built here by Foster Wheeler



Here at Lake Charles, Louisiana, Petroleum Chemicals, Inc. will expand its petrochemical facilities with the addition of a butyl rubber plant — to be built by Foster Wheeler.

With an initial capacity of 30,000 tons per year, this $17,000,000 plant will be the first one built since the war and its operation will increase the country's total butyl rubber capacity by about one third. This new plant will obtain its raw materials from the hydrocarbon streams available at the Lake Charles refineries of Cities Service and Continental Oil Companies, joint owners of Petroleum Chemicals, Inc.

Foster Wheeler is also building a 300 ton/day ammonia synthesis plant at the same site.

This is another example of how Foster Wheeler's design, engineering and construction experience is helping to meet the exact requirements of petroleum, chemical and petrochemical processing plants the world over.

Foster Wheeler Corporation, 165 Broadway, New York 6, N. Y.

FOSTER WHEELER DESIGNS AND BUILDS
PETROLEUM, CHEMICAL AND PETROCHEMICAL PROCESSING PLANTS
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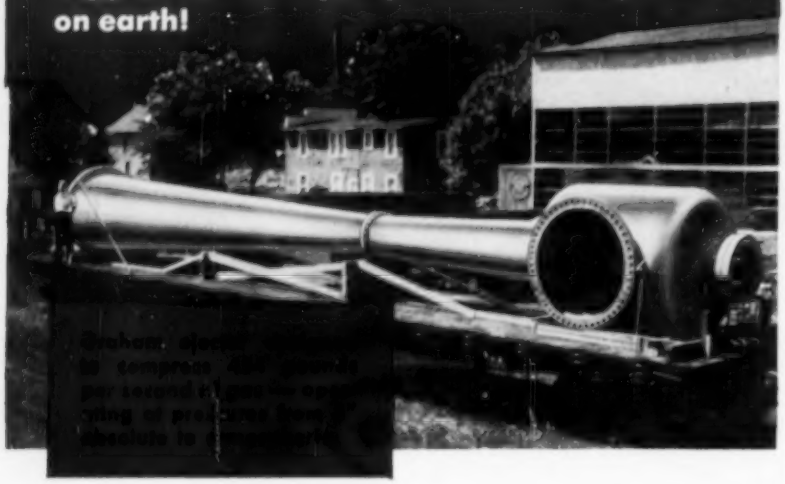
. . . or more properly, we might say . . . the biggest vacuum pump (thermo-compressor) on earth!



If your vacuum problem requires a steam or gas operated ejector, capable of sustaining accurately predicted absolute pressures throughout a given range — then come to Graham.

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We are vacuum specialists and are equipped to quickly deliver to you *any type of ejector*, from the smallest single stage unit — selling for just a few dollars — up to the most involved and modern type, produced for industry's more complicated requirements.

Send us your inquiry. A conference with our engineers in no way obligates you.

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[illegible]

INDUSTRIAL NEWS

Boron trichloride and boron tribromide are now being produced at American Potash & Chemical Corp.'s Los Angeles plant. A semi-continuous process developed recently by the company's research department has brought the price of the trichloride from $3.00 to $1.60 a pound. This marks the first commercial-scale production of boron tribromide. □

Ground has been broken for a new $1.5 million refractories plant at Worcester, Mass., by the Norton Company. Plant will have complete modern facilities for the straight line production of heavy refractories for high temperature applications. □

New bromine plant is in operation at El Dorado, Ark., as a joint project of Michigan Chemical Corp. and the Murphy Corp. □

Annual capacity of polyethylene at Texas Eastman's Longview, Tex., plant has been increased to 55 million pounds. This is the second substantial increase by the subsidiary of Eastman Kodak. □

Work has begun on the construction of a 40,000 barrel a day refinery for the Texas Co. at Anacortes, Wash. Completion is scheduled for January, 1959. General construction is being done by the Bechtel Corp., furnishing and erection of tankage by Chicago Bridge and Iron Co. □

Layne & Bowler, Inc., pioneering ground water pump manufacturing and drilling firm, is celebrating its 75th Anniversary this year. One of the leading companies in the water field, a vital factor in the chemical and other industries, Layne's Research Division is the only one devoted solely to the problems of ground water supply development. □

A complete instrumentation-and-control system maintenance contract has been awarded by Tidewater Oil Company to Panellit Service Corp. Contract covers Tidewater's giant Delaware City, Delaware, refinery. □

The first stage of production is now underway at Southern Nitrogen Co.'s new $14 million nitrogen manufacturing plant in Savannah, Ga. The plant is now producing ammonia, will be producing nitrogen manufacturing solutions by March and solid ammonium nitrate by April. Ammonia capacity is 250 tons a day. □

Quarter-inch steel plate is melted with an acetylene torch, but the supporting ALFRAX® BI brick stays cool enough to be held by hand.

Refractories...for really high temperature **insulation**

The problem of heat insulation at extreme temperatures is solved by two of Carborundum's refractories:

One is made of fused alumina "bubbles" or hollow spheres, bonded and high fired. These selected bubbles give proper balance between the number of surface temperature drops and total pore space (about 65% porosity) to effectively decrease heat flow between hot and cold faces. The alumina imparts high hot strength to the finished refractory, trade-marked ALFRAX BI. Under a load of 12½ psi and a temperature of 2732° F held for 1¾ hrs., less than 1% contraction occurred. No contraction whatever developed in 5 hour reheat tests at 3092° F. This combination of properties makes ALFRAX BI refractories unique in their ability to insulate at temperatures where other materials are impractical.

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TURN FOR MORE NEWS ON
INDUSTRY ..... page 54 et seq.
RESEARCH ..... page 90
OVERSEAS ..... page 104
INSTITUTIONAL ..... page 111

VAST NEW CUBAN NICKEL OPERATIONS EXPECTED TO CONTRIBUTE SIGNIFICANTLY TO U. S. NEEDS

$100,000,000 nickel and cobalt plant of Freeport Sulphur will use chemical process to by-pass smelter; 50 million pounds of nickel metal and 4.4 million pounds of cobalt metal will be produced annually from Cuban ores by a new high-pressure process. Also: Nicaro expands Cuban nickel production by 75%.

Freeport Sulphur announced recently that its subsidiary, Cuban American Nickel Co., has signed a contract with the U. S. Government according to which the government will buy nickel and cobalt metal from new facilities to be built in Cuba and the U. S. The announcement follows successful completion of operations at a pilot plant in Louisiana which was designed to treat 50 tons of ore per day.

The $100,000,000 project is based on large reserves of nickel-cobalt ores owned by Freeport subsidiaries at Moa Bay, Cuba. The limonite ore at Moa Bay is said to average 1.35 per cent nickel and 0.14 per cent cobalt. Proven reserves are stated to amount to more than 50 million tons of ore. The ore will be mined from open pits and will be chemically beneficiated at Moa Bay by sulfuric acid leaching. The resulting concentrates will be shipped to the U. S. for final chemical separation of the nickel and cobalt.

Smelting Eliminated

The chemical separation plant, which will probably be located on the Gulf Coast, will employ the Chemico (Chemical Construction Corp.) process which by-passes traditional smelting steps to produce high-purity metals by direct chemical reduction from solution with reducing gas. While no authoritative technical data is available on the details of the process Freeport will use, it can be conjectured that the reduction step, using hydrogen or hydrogen-containing reform gas, will probably involve pressures in the neighborhood of 500 to 600 lb./sq. in. or higher, and temperatures in the range of 300 to 400° F. The reductions will probably be carried out continuously in mechanically-agitated autoclaves.

With the announcement of the completion of pilot plant work, it is evident that Freeport has cracked most of the tough chemical engineering problems involved, such as the feeding and discharge of metal slurries at elevated pressures and temperatures. It is also evident that they have succeeded in effecting the difficult chemical separation of nickel and cobalt to a degree where metals of commercially acceptable purity can be produced. The basis for the chemical separation of nickel and cobalt is believed to be the complexing of the cobalt in the so-called Werner coordination compounds. This step requires ammonia; therefore, one by-product of Freeport's plant will be a certain amount of ammonium sulfate.

The Freeport undertaking is believed to be the fourth and largest application to date of the Chemico metals technique. The others are: the nickel operation of Sherritt-Gordon Mines Limited in Alberta, Canada; the cobalt plant of Howe Sound Mining in Salt

(*Continued on page 54*)

CALVERT CITY CHEMICAL COMPLEX CONTINUES TO EXPAND

Latest addition to the chemical center at Calvert City, Ky., is Air Reduction's methyl butynol plant. First of its type in the U. S., the new plant is only one of Air Reduction's new facilities. Another is the new multi-million-dollar air separation and liquifaction plant at Bassett, Cal.

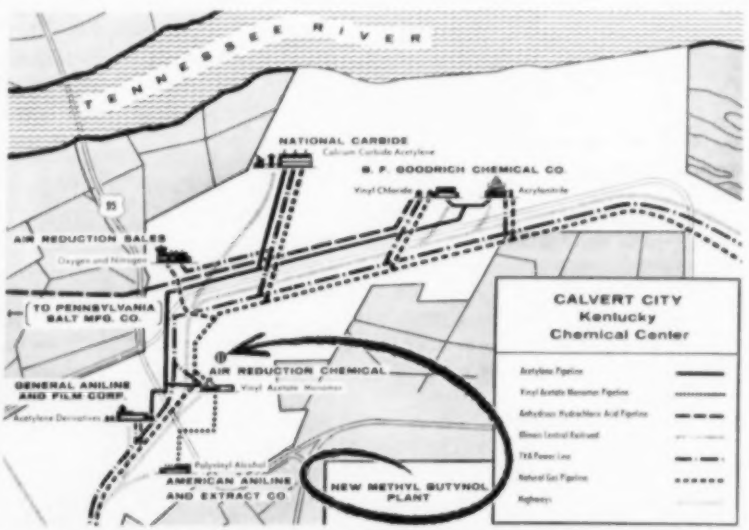
Air Reduction's new methyl butynol plant is its fourth plant in Calvert City. The major chemical manufacturing center is continuing to grow, is highly integrated, is closely connected plant-to-plant by pipeline.

Scheduled to move into production by the end of the year, the methyl butynol plant is the first commercial, continuous-process producing unit for the tertiary acetylenic alcohol in the U. S. With an annual capacity of 3 million pounds, the plant uses a process developed by Air Reduction involving the reaction of acetylene and acetone using a basic catalyst.

Major application of methyl butynol is as a starting material in the manufacture of many chemicals based on its three points of reaction: the triple bond, the hydroxyl group, and acetylenic hydrogen. Used directly, the chemical is an acid corrosion inhibitor, a scavenger of HCl in chlorinated compounds, and is a specialty solvent.

Air Separation Plant

Air Reduction's new air separation plant at Bassett, Cal., is now under construction, will cost $7.5 million, will produce 55 tons of high purity liquid oxygen, 15 tons of liquid nitrogen, and 3.5 tons of liquid argon each day. When completed, the Bassett plant will be the fourth of its type for Air Reduction.



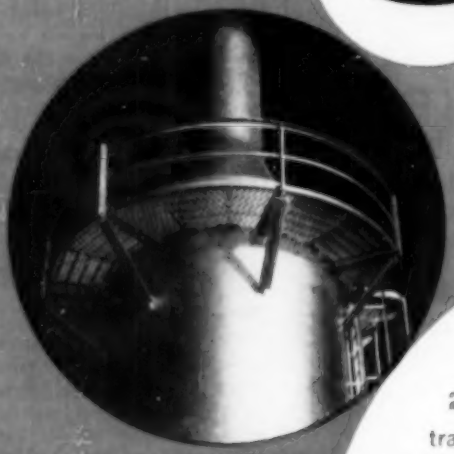
Just part of the chemical complex at Calvert City, the unshaded area shows Air Reduction's 1,500-acre site assembled for its own and customer's plants.

you can judge

the comparative values of furnace design as applied to operating requirements.

It's quite simple

there are 9 basic factors which must be evaluated to obtain the full comparison of values



1—Average radiant transfer rate. 2—Maximum deviation from average radiant transfer rate. 3—Average and maximum transfer rate in convection section. 4—Maximum tube wall temperature, radiant or convection. 5—Maximum efficiency with specified excess air. 6—Controlled thermal recirculation of flue gases to provide even heat distribution throughout full length of each tube and equalized heat distribution around each tube. 7—Overload and corresponding transfer load. 8—Design to provide: structural column supports · Ladders · Platforms · Tube Removal facilities, etc. 9—Degree of assembly; of the furnace structure and of the heating surface.

Whenever all these 9 specifications are applied to all the operating requirements, you can be sure PETROCHEM ISOFLOW FURNACES will be found most economically desirable.
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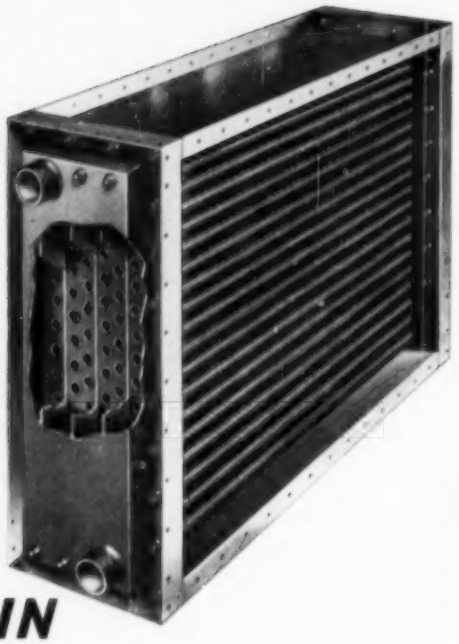

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CUBAN NICKEL

(*Continued from page 52*)

Lake City; and the small plant of the Whitaker Cable Co. in Kansas City, where copper-bearing scrap is processed chemically to obtain a relatively pure copper powder.

Nicaro Expansion

National Lead Co. recently announced the completion of a 75 per cent expansion program at the U. S. Government-owned nickel producing facilities at Nicaro, Cuba. The expansion will bring rated capacity at Nicaro to 50 million pounds of nickel per year, or an amount equal to the planned production of the new Freeport venture. The metallurgical leaching process used at Nicaro differs from the Chemico process in that the nickel oxide produced at the Nicaro Cuban plant must be subsequently refined by conventional smelting methods. This will be done at a new smelting plant of National Lead Co. in Crum Lynne, Pennsylvania.

Defense Significance

The Freeport and Nicaro operations together, when in full production, will considerably relieve U. S. dependence on Canadian nickel which, in 1956, made up about 80 per cent of the free world's supply. In addition, the Freeport plant is expected to be the biggest producer of cobalt in the Western Hemisphere and will thus help to assure our continuing supply of this vital strategic metal.

High Voltage Engineering Corp. is now moving to its new location in Burlington, Mass., 15 miles north of Boston. Until the move is complete, radiation services and some final accelerator assembly work will continue at the Cambridge plant. □

A benzene unit designed to produce some 24 million gallons per year of purified benzene is being designed, engineered, and constructed by Badger Manufacturing Co. for Humble Oil & Refining Co. at the latter's Baytown, Tex., refinery. Expected to go on-stream by December 1957, the unit will use the Udex process of Universal Oil Products Co. □

An improved type of insoluble sulfur for use in rubber compounding has been developed by Stauffer Chemical Co.'s Research and Development Dept. and will soon be on the market. □

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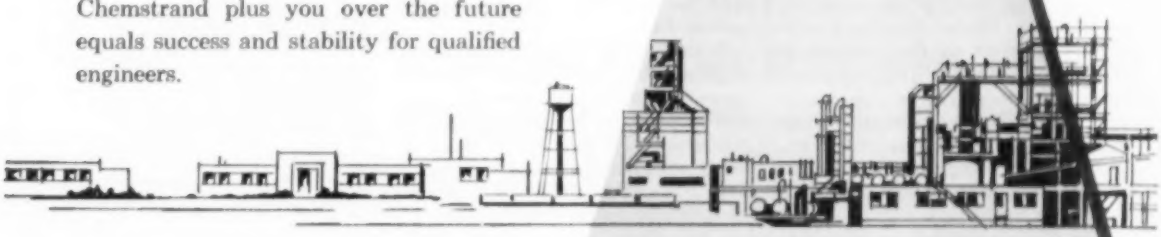

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INORGANIC CHEMICALS FUTURE

(*Continued from page 44-a*)

and in many areas supplies are diminishing. Either ground water reserves are being exhausted, or surface and ground waters are being polluted. Man-made pollution has caused much of the extreme downgrading of supply and is characteristic of nearly all heavily inhabited watersheds. It is most serious in the manufacturing belt from Chicago and St. Louis eastward to the Atlantic Coast. There are many cases where access to good water has been one of the most important factors in deciding where to locate industries.

Even when volume of water supply is plentiful, some serious shortages have developed because the supply is not fit to use. Uncleanliness and saltiness are the chief reasons, but not the only ones. Demineralizing of saline waters for industrial use is under study by the Dept. of Interior in cooperation with private manufacturers. So far, ion-exchange membrane units hold promise of supplying demineralized water at 60 cents/thousand gallons, a figure presumed to be within range of certain types of process-location combinations.

Closed-system recycling of both process and cooling water has helped. Many chemical manufacturers have established within their own organizations special research groups whose primary function is to study methods of pollution abatement. In many cases these groups have been able to develop processes which showed an actual profit to the company through recovery of valuable materials previously discarded in their waste water or gases. The chemical industry is under obligation to make sure that any existing process, or any proposed new process, is provided with proper facilities to avoid pollution of adjacent waters. If these steps are not taken voluntarily by the industry, they will almost certainly be imposed by governmental agency action.

The examples used so far in this discussion have been connected with traditional technology; they illustrate processes which have for years formed the backbone of the chemical industry. Within the past few years, however, there has emerged a new type of inorganic technology which has stemmed in large part from wartime military requirements. For years the spectacular developments in chemistry which made newspaper headlines have been largely in the organic field. More recently the trend has been to emphasize the "wonder fuels" and the "magic metals." The cycle of development seems to be swinging toward the inorganic field again.

It is not yet possible to say with any certainty how big an impact nuclear energy for peacetime uses will have on inorganic chemicals and the chemical industry as a whole. Former Atomic Energy Commissioner Henry Smythe recently summed up the importance of fuel reprocessing and waste disposal when he said "The nuclear power industry will stand or fall economically depending on the success the chemists and chemical engineers have in developing cheap processes for purifying and refabricating nuclear fuel."

In addition to the widely publicized emphasis on the fissionable materials, nuclear technology has directed attention to a number of other metals and inorganic materials which until recently have been in the rare classification. For example, the A.E.C. recently awarded contracts for the purchase of 2.2 million pounds of zirconium during each of the next five years.

In the case of titanium, intensive research has been carried out over the past several years in an effort to develop commercial processes for recovery of the metal in usable physical form at a cost which would not be prohibitive. The metal's unique adaptability to such purposes as jet engine parts, airplane structural members and corrosion resistant chemical processing equipment practically insures that investigation of these processes will continue until success has been attained.

Titanium is estimated to be the ninth most abundant element in the earth's crust; however, the only titanium ore deposits of present commercial importance are rutile and ilmenite. Both of these materials are available in substantial quantities in the North American continent—the largest deposits probably being the ilmenite-hematite mixture in Quebec. The slag obtained in the smelting of this ore for recovery of its iron content is one of the most promising sources for titanium production. Rutile deposits are available in various parts of the United States and in Mexico, and there has been substantial activity in Florida where titanium and zirconium minerals are available from beach sands. The problem of raw materials for the titanium industry appears to be principally the determination of which ore lends itself most advantageously to economic recovery of the titanium content rather than any shortage of the actual material itself.

High Energy Fuels

In the field of energy production, recent interest has not been centered solely on uranium and thorium. Announcement has been made of a contract being awarded for the development of the best possible chemical for powering aircraft, using a type of high energy fuel based on boron or lithium. Work on both is progressing, but as one Air Force official put it, "We have to develop the chemical before we decide on the engine." This points to the possibility of a future for boron compounds far more exciting than had previously been visualized.

The principal source of boron is borax which is available in very large quantities in the desert regions of Southern California. This material is obtained both by mining and by processing of the brines from the semi-dry lakes of the region. The organo-boron compounds seem to be of primary interest in this connection because of their light weight and high energy, which makes them particularly adaptable as fuel ingredients for rockets, guided missiles, and supersonic aircraft. It has been estimated that the interest in organo-boron compounds will increase the demand for borax from the present figure of 900,000 tons/year up to 2½ million tons/year by 1965. There appears to be no question of availability of sufficient raw materials to satisfy the demands in this development.

There has been a sensational growth of the demand for lithium chemicals. Why? Because of the numerous uses that have been suggested for them in the chemical process industries. These include use as a reducing agent in organic reactions; catalysts in polymer technology; raw materials for metal hydrides and boro-hydrides; oil additives; bleaches; gas absorption; refrigeration fluids; and propellants. Production in 1953 was approximately 5 million pounds. It has been forecast that this will increase to 30 million pounds by 1960. This rapid expansion has been made possible by the development of processes which permitted the use of low grade ores available in very large quantities in the United States.

It can therefore be seen that there is a continuous thread throughout the entire fabric—that thread is the role of the chemical engineer and chemist in surmounting the ever-increasing difficulties faced by the

(*Continued on page 58*)

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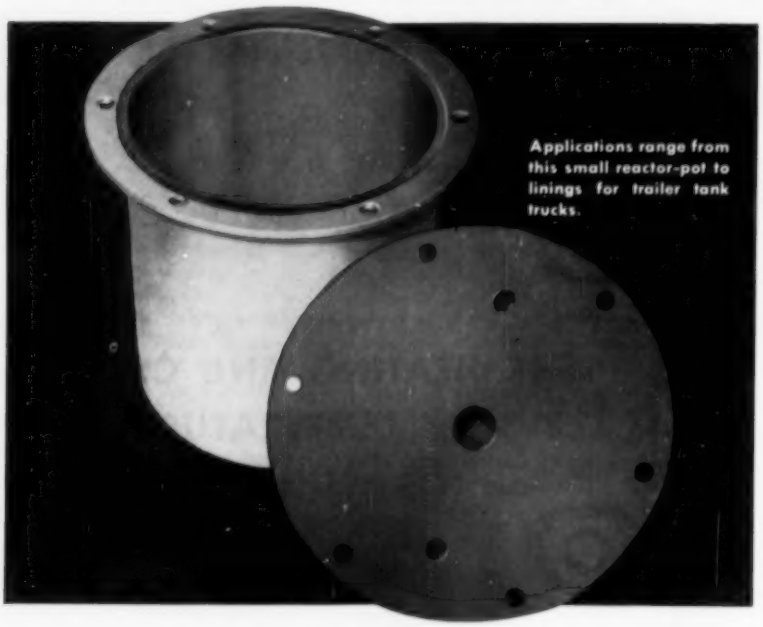

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United States Gasket *Plastics Division*

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INORGANIC CHEMICALS

(Continued from page 56)

industry in connection with the supply of raw materials. It is evident that the supply of these vital materials for our industry presents a more serious problem today than it did 20 years ago. It will be worse 20 years hence than it is now. Although the resources of the United States are abundant, they are not inexhaustible. We and our fathers have in many cases used up the easily available supplies of essential raw materials. In some cases there will be discovery of additional sources of such high grade material, but in other cases it will be necessary to turn to alternative supplies, the use of which will require more and more ingenuity. These new problems will be met in various ways. In some cases it may mean relocation of the manufacturing plant itself.

This is directly contrary to usual past practice. In this instance, nearness to product markets overbalances the desirability of proximity to the source of the essential salt. In other cases, modifications to the manufacturing process will have to be developed to accommodate it to the new type of raw materials. But whatever method of approaching the solution of the problem is adopted, it means that chemical engineers and chemists are faced with a challenging opportunity to maintain our particular segment of the industry in a competitive position with the rest of the field.

There are, of course, a few instances where, according to our best present knowledge, certain raw materials are simply not available in the United States. In these cases the necessary supplies will have to be imported until such time as new discovery fills in the gap. In most cases, however, the chemical industry's requirements are available in almost unlimited quantities in the United States in one form or another. The future of raw materials for inorganic chemicals lies fully as much in the intelligence and imagination of our chemical engineers and chemists as it does in our mines, quarries, and wells. A constant increase in the productivity of the one must offset any possible decrease in the productivity of the other. Another way to state this is that our future depends not on money or capital, not on plants or processes—not even on raw materials, but in the final analysis on our scientists and technologists—their training, attitudes, and ingenuity.

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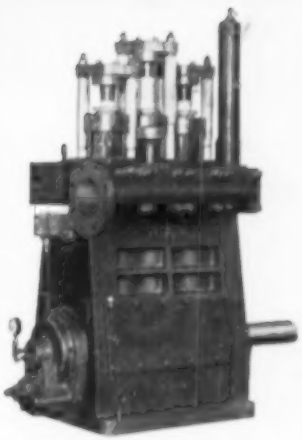

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CEP Data Service

DEVELOPMENTS OF THE MONTH

382 All-Plastic Y-Globe Valve. Made of rigid polyvinyl chloride, the new PVC valve provides tight shutoff and flow control of alkalis, acids, inorganic salt solutions, and other corrosive fluids used in the food, oil, gas, petrochemical, chemical, paper, and allied industries. A special bonnet and gland nut assures an absolutely leak-proof unit. The valve is said to operate successfully at pressures up to 150 lb./sq.in. at 75° F. The life of the packing is prolonged through a tapered back seat on the stem which permits repacking under pressure. The same design also reduces pressure on stem packing when valve is opened completely. The new valve is now available for 1 inch pipe. The manufacturer says that other sizes, from ½ through 2 inches, will be available soon. Walworth Company. Circle number 382 on Data Post Card for further information.

ENGINEERING DATA—MATERIALS

301 Lining Data Sheets. Technical data and resistance chart on "Lithcote" baked-on phenolic resin coatings and linings. Lithcote Corp.

302 Plastic Engineering Data. Evaluation and specification data on Teflon, Zytel (nylon resin), Alathon (polyethylene resin), and Lucite (acrylic resin). Brochure from DuPont.

303 Extruded Tubing. Seamless alloy and stainless steel extruded tubing for high-pressure, temperature, and corrosion resistant applications. Brochure from Metals Processing Division, Curtiss-Wright Corp.

304 Paper Mill Pipe and Fittings. Stainless pipe and fittings specifically designed to withstand corrosion and contamination in pulp and paper mills. Bulletin from Swepco Tube Corp.

305 Molybdenum Disulfide Filler. Bulletin from Climax Molybdenum Co. describes addition of molybdenum disulfide to plastics to improve frictional and mechanical properties.

306 Low-Cost Methallyl Chloride. Comprehensive review of methallyl chloride chemistry, with suggested applications and bibliography available from Organic Chemicals Division, Food Machinery and Chemical Corp.

307 Piperazine Booklet. Properties, reactions and uses, toxicological, and handling information. Dow Chemical Co.

308 Fiberglass-Reinforced Resin. Provides complete corrosion resistance to wider range of conditions than polyester resins. Haveg Industries, Inc. Literature.

309 Teflon Products. Heavy-walled tubing, rods, spaghetti tubing, flexible tubing. Data sheets from Pennsylvania Fluorocarbon Co.

310 Corrosion Data. Reprint of paper, "High-Temperature Problems in Process Plants," discusses use of steel and alloys in high-temperature and corrosive service. Babcock & Wilcox Co.

311 Stainless and Alloy Tubing. Mechanical, capillary, and hypodermic tubing from .008 to 1 in. O.D. in stainless, nickel, and nickel alloys. Bulletin from J. Bishop & Co. Platinum Works.

312 Silicone Fluids Reference Brochure. Specific gravity, pour point, thermal conductivity, surface tension, refractive index, dissipation factor, specific heat of all leading silicone fluids. Dow Corning Corp.

314 Chemical Index. 1957 edition of Chemical Index published by Reilly Tar & Chemical Corp. Includes information on 8 new chemicals developed in 1956.

315 Technical Notes on Menthane Diamine. Discussion of various reactions and possible applications. Samples also available. Rohm & Haas Co.

316 Centrifugal Castings. Also finished machined products in large variety of alloys. Bulletin from Janney Cylinder Co.

317 Liquid Defoamer. Bulletin from Air Reduction Chemical Co. describes Surfynol 104A for use in aqueous systems where foaming is a process problem.

318 Linear Type Polyethylene. Can replace lead as shielding in atomic reactors. Also available molded into rings, spheres, rods, etc. Technical data from American Agile Corp.

(Continued on page 66)

DEVELOPMENTS OF THE MONTH (Cont.)

383 Filters for Large Pipes. A new line of gas and air filters for 6 in., 8 in. and larger pipe sizes has been introduced by the Norwalk Valve Co.

The filters are equipped with a patented built-in baffle that assures maximum passage of gases and air through the filtering material and permits complete removal of dust and scale. As an added feature, the filters are reversible end-for-end and top-for-bottom, which eliminates the possibility of improper installation in the field. Circle number 383 on Data Post Card for further information.

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DEVELOPMENTS OF THE MONTH

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ENGINEERING DATA—MATERIALS

301 Lining Data Sheets. Technical data and resistance chart on "Lithcote" baked-on phenolic resin coatings and linings. Lithcote Corp.

302 Plastic Engineering Data. Evaluation and specification data on Teflon, Zytel (nylon resin), Alathon (polyethylene resin), and Lucite (acrylic resin). Brochure from DuPont.

303 Extruded Tubing. Seamless alloy and stainless steel extruded tubing for high-pressure, temperature, and corrosion resistant applications. Brochure from Metals Processing Division, Curtiss-Wright Corp.

304 Paper Mill Pipe and Fittings. Stainless pipe and fittings specifically designed to withstand corrosion and contamination in pulp and paper mills. Bulletin from Swepco Tube Corp.

305 Molybdenum Disulfide Filler. Bulletin from Climax Molybdenum Co. describes addition of molybdenum disulfide to plastics to improve frictional and mechanical properties.

306 Low-Cost Methallyl Chloride. Comprehensive review of methallyl chloride chemistry, with suggested applications and bibliography available from Organic Chemicals Division, Food Machinery and Chemical Corp.

307 Piperazine Booklet. Properties, reactions and uses, toxicological, and handling information. Dow Chemical Co.

308 Fiberglass-Reinforced Resin. Provides complete corrosion resistance to wider range of conditions than polyester resins. Haveg Industries, Inc. Literature.

309 Teflon Products. Heavy-walled tubing, rods, spaghetti tubing, flexible tubing. Data sheets from Pennsylvania Fluorocarbon Co.

310 Corrosion Data. Reprint of paper, "High-Temperature Problems in Process Plants," discusses use of steel and alloys in high-temperature and corrosive service. Babcock & Wilcox Co.

311 Stainless and Alloy Tubing. Mechanical, capillary, and hypodermic tubing from .008 to 1 in. O.D. in stainless, nickel, and nickel alloys. Bulletin from J. Bishop & Co. Platinum Works.

312 Silicone Fluids Reference Brochure. Specific gravity, pour point, thermal conductivity, surface tension, refractive index, dissipation factor, specific heat of all leading silicone fluids. Dow Corning Corp.

314 Chemical Index. 1957 edition of Chemical Index published by Reilly Tar & Chemical Corp. Includes information on 8 new chemicals developed in 1956.

315 Technical Notes on Menthane Diamine. Discussion of various reactions and possible applications. Samples also available. Rohm & Haas Co.

316 Centrifugal Castings. Also finished machined products in large variety of alloys. Bulletin from Janney Cylinder Co.

317 Liquid Defoamer. Bulletin from Air Reduction Chemical Co. describes Surfynol 104A for use in aqueous systems where foaming is a process problem.

318 Linear Type Polyethylene. Can replace lead as shielding in atomic reactors. Also available molded into rings, spheres, rods, etc. Technical data from American Agile Corp.

(Continued on page 66)

DEVELOPMENTS OF THE MONTH (*Cont.*)

383 Filters for Large Pipes. A new line of gas and air filters for 6 in., 8 in. and larger pipe sizes has been introduced by the Norwalk Valve Co.

The filters are equipped with a patented built-in baffle that assures maximum passage of gases and air through the filtering material and permits complete removal of dust and scale. As an added feature, the filters are reversible end-for-end and top-for-bottom, which eliminates the possibility of improper installation in the field. Circle number 383 on Data Post Card for further information.

DEVELOPMENTS OF THE MONTH (Cont.)

384 Large Size Haveg Ducts. These 15 inch diameter polyester glass fume ducts, produced by Haveg Industries, Inc. are molded into a single piece. Glass smooth inside and out, they are claimed to provide high resistance to chemical corrosion of acids, hypochloride salts, weak alkalies, and many inorganic solvents. The line has recently been expanded to include standard sizes to 24 inches in both rectangular and circular ducts. Special sizes and shapes are produced to customer's specifications. Circle number 384 on Data Post Card for further information.

(Continued on page 63)

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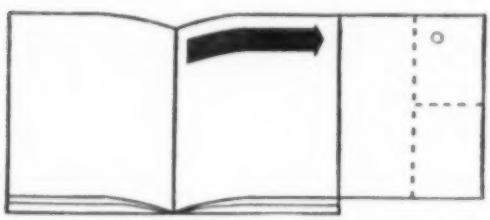

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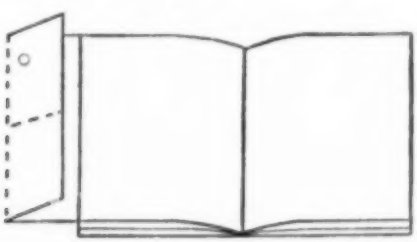

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DEVELOPMENTS OF THE MONTH (Cont.)

385 Steam-Traced Piping. One-piece, steam-traced piping with a cross-section matching standard pipe sizes is now available from the Aluminum Co. of America in nominal sizes of 1½, 2, 3, and 4 in. Immediate advantages to users are said to be lower cost per foot and easier, faster installation. This has been accomplished by increasing the transfer of heat internally and cutting the heat loss from external radiation. Booklet giving installation and performance is available from the manufacturer. Circle number 385 on Data Post Card for further information.

386 Pilot Plant Spray Dryer. Proctor & Schwartz announces introduction of new pilot plant and semi-works spray dryers. The basic dryers are said to be ideally suited to studies of spray drying problems and to small production runs of ordinary products. Modifications, easily made in the plant, adapt the basic units for use with viscous materials, for the production of hollow spheres or thin walled "beads," or for conversion to a "dispersion" type dryer. Accessory groups for these conversions are readily available.

All parts exposed to the product are type 304 stainless steel. Steam, gas or electric heating units are available. Standard motors and structural supports are provided. Two fluid atomizers are normally provided, but centrifugal atomizers can be supplied.

Evaporation rates of the basic units are 15 to 75 and 30 to 150 pounds of water per hour, with increases to 200 and 400 pounds per hour possible with the "dispersion" dryers. Circle 386 on Data Post Card for further information.

387 Entrainment Manual. Prepared especially for process engineers and designers, the new 16-page "Schuylernit" Manual is concisely written and clearly illustrated to show the design, application and performance of mist eliminators in chemical and petroleum process vessels.

Said to be the most complete and informative manual available, the book explains and solves many liquid entrainment problems in scrubbers, absorbers, evaporators, knock-out drums, cracking towers, and distillation equipment. Schuyler Manufacturing Corp. Circle number 387 on Data Post Card for further information.

(Continued on page 70)

PRODUCTS ADVERTISED IN THIS ISSUE

IFC Ethanol Plant Design and Construction. Vulcan Engineering Division's experience in ethanol goes back over 55 years, covers hundreds of installations.

3R Mechanical Packer. Several sizes of Vibrox packers available for packing boxes, cans, cartons, kegs, drums, and barrels. Bulletin from B. F. Gump Co.

4A Demisters. Bulletin from Otto H. York Co. covers performance data on Yorkmesh Demisters. Also list of case histories.

6A-7A Equipment Fabrication. The Graver Tank & Mfg. Co. was called on to fabricate, erect, and test the housing for the Experimental Boiling Water Reactor at Argonne National Laboratory.

9A Filtration Consulting Service. Eimco Corp.'s Research and Development Center will help you choose the proper unit for your filtration problem.

10L Corrosion Resistant Equipment. Bulletins from Haveg Industries, Inc. describe complete line of plastic processing equipment.

11A Mercury Arc Rectifiers. Separation of firing circuit and phase control circuit assures optimum operation. Allis-Chalmers.

12L Mechanical Shaft Seals. Positive trouble-free seal around rotating shafts. Complete catalog from Syntron Co.

13A Particle Size Analyzer. The Micromerograph, made by the Sharples Corp., can provide rapid reproducible particle size distribution determinations at production speed. Accuracy within 3%. Technical bulletin.

14A Continuous Centrifuges. Effective in handling slurries up to 35% solids. Bulletin from Pfaudler Co. describes the Titan Superjector.

15A Recording Instruments. Complete detailed report on the multiple applications available in Ratographic instruments offered by the Fischer & Porter Co.

16A Continuous Reactors. Rigid heat control and complete dispersion of reactants. Brochure from the Girdler Co. gives details of the Votator continuous reactor.

17A Turba-Film Processor. Permits a high degree of solvent removal with greater throughput than conventional equipment. Details from Rodney Hunt Machine Co.

18A Temperature and Pressure Regulator. The Duo-matic Leslie temperature regulator for steam flow automatically controls both temperature and pressure conditions. Leslie Co.

19A-20A Chemical Product Information. U.S.I. Chemical News describes new developments and products of U. S. Industrial Chemicals Co.

23A Tubing for Atomic Power. Design and construction of intricate reactor components of special types. Literature from Superior Tube Co.

24B Fabricated Steel Structures. Tanks, digesters, pressure vessels, stacks. Posey Iron Works, Inc.

25A Impervious Graphite Products. Catalog available from National Carbon Co. describes impervious graphite heat exchangers, entrainment separators, pumps, etc.

26A-27A Computer in Engineering Design. Large magnetic drum computer enables M. W. Kellogg's engineers to study variables, produce results with thoroughness, accuracy, and speed with human error practically eliminated.

29A Design and Construction Services. Plants for chemicals, resins and plastics, petroleum and petrochemicals, fertilizers, fats and oils, chlorine and alkali, nuclear energy, synthetic fuels, waste recovery. Blaw-Knox Co.

30L Laboratory Planning Service. Metalab Equipment Co. offers economical, adaptable, functional equipment. Consulting and planning services free.

31A Custom-Engineered Crystallizer. Laboratory or pilot plant tests on crystallization problems offered by Struthers Wells Corp. Bulletin.

32A Diaphragm Control Valves. Extra thick casings, bolted gland stuffing boxes, large capacity bodies. Details from Fisher Governor Co.

33A Plant and Equipment Design. Brochure from Southwestern Engineering Co. describes their design and engineering facilities and experience.

35A Compacting Process. Consisting of compacting mill, roller mill, and gyratory screen, the Allis-Chalmers compacting process can turn worthless material into profits. Bulletin.

36L Tantalum Test Kit. Corrosion test kit, available without charge to research technicians, contains both tantalum sheet and wire. Fansteel Metallurgical Corp.

37A Leak-Proof Pump. The "Chempump" combines pump and motor in single unit. No shaft sealing device required. Details from Chempump Corp.

38A-39A Mineral Fillers. Celite, product of Johns-Manville, comes in wide range of grades, each controlled for complete uniformity. Literature.

40L Jobs for Designers. Process, equipment, mechanical, instrument designers wanted by DuPont. Many benefits.

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42A Process Equipment Fabrication. Heat exchangers, containers, and pressure vessels for gases, liquids, and solids. Bulletins from Downingtown Iron Works.

44A Controlled-Volume Chemical Pump. The Lapp Pulsafeeder is a combination piston-diaphragm pump for controlled-volume pumping. Bulletin with flow charts and specifications. Lapp Insulator Co.

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45A New Design Turbo-Mixer. Side-entering propeller series available in sizes from 1 to 30 horsepower. Bulletins from Turbo-Mixer Division, General American Transportation Corp.

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50L Vacuum Equipment. Graham Manufacturing Co. offers all types of vacuum ejectors from the smallest to the most involved modern types. Consulting services.

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51A High-Temperature Refractories. Bulletins from Carborundum Co. give technical details on two new "super refractories," Alfrax BI and Fiberfrax.

53A Industrial Furnaces. Since 1940, more than 1,650 Petro-Chem "Isoflow" furnaces are in operation or under construction. Petro-Chem Development Co.

54L Removable-Header Water Coils. Complete drainability, easily cleaned, high heat transfer. Bulletin from Aerofin Corp.

55A Engineering Jobs. Immediate openings for chemical, mechanical, industrial, textile, and instrument engineers. Chemstrand Corp.

57A Heat Transfer Test Unit. Process heat transfer with molten eutectic salt at 650 to 1,000° F. accomplished with compact pilot unit. Illustrated descriptive folder. Bethlehem Foundry & Machine Co.

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(Continued on page 70)

How electronics makes P-K exchangers better than ever

This man is expanding tube ends into the tube sheet—the "inner face" of a shell and tube heat exchanger that holds each tube in place. By doing it electronically, with the equipment you see here, the circumference of each tube is joined to the face of the exchanger with exactly the same pressure.

This minimizes the possibility of leaks developing—even when a mile of tubing and hundreds of tube ends are involved, as they are in many of P-K's special exchangers.

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MATERIALS (*Cont.*)

319 Asbestos Fiber Gasketing Materials. Effective at flange temperatures to 500° F. and internal liquid pressures to 500 lb./sq.in. Available as roll goods, sheets, die-cut parts. Armstrong Cork Co.

320 Carbon-Based Filteraid. Nerofil, product of Great Lakes Carbon Corp., is said to be an entirely new type of filteraid, made from a special form of carbon, processed to give filtering qualities. Technical Bulletin.

321 Free-Flowing High Purity Piperazine. Available in commercial quantities. Derivatives are proposed for use as rubber accelerators and stabilizers, surface active agents, resins, and polymers. Jefferson Chemical Co.

322 Plastics Catalog and Price List. 62-page catalog lists sheets, rods, and tubes in Lucite, Plexiglas, Vinylite, Polystyrene, Polyethylene, and many other plastics. Kaufman Glass Co.

323 Report on Protective Coatings. Comprehensive brochure discusses organic, inorganic, metallic, and combination coatings and linings. Sample specification sheets. Metalweld, Inc.

324 Titanium and Zirconium Electrodes. Bulletin gives maximum sizes, rough weights of consumable electrodes in titanium, zirconium, and other refractory metals. Oregon Metallurgical Corp.

325 Polyamide Tubing Bulletin. "Nylaflow" pressure tubing described in brochure from The Polymer Corp. of Pennsylvania. Available sizes and installation information.

326 Lead Linings. Republic lead linings, homogeneously bonded to steel, are unexcelled for corrosive conditions. Bulletin from Republic Lead Equipment Co.

327 High-Temperature Insulating Material. T-9278 insulating material is made of flexible straight-weave continuous-filament glass fabric coated with a modified silicone resin. Technical data from Westinghouse Electric Corp.

328 High-Temperature Brazing Alloys. Four-page catalog from Wall Colmonoy Corp. gives shear strength, elongation, oxidation resistance, tensile strength of Nicrobraz brazing alloys. Illustrated charts.

329 Plastic-Coated Pipe and Tubing. Four-page folder gives details of X-Tru-Coat pipe and tubing, product of Republic Steel Corp.

330 Spun Steel Tubing. Useful technical data and information for solving tubular product problems. 64-page bulletin from American Cast Iron Pipe Co.

SERVICES

331 Interpretive Research. The Selas Corporation of America specializes in the creation, development, and application of precise heat and fluid processing techniques and materials. Design and construction services.

332 Safe Handling Chart for Caustic Soda. Wall chart on safe handling and unloading of caustic soda tank cars offered by Solvay Process Division, Allied Chemical & Dye.

333 Plants and Processes for Fats and Oils. Complete engineering and construction services offered by Blaw-Knox Co. described in 20-page bulletin.

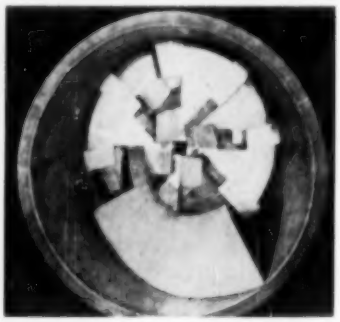
334 Nuclear Consulting Services. From experimental work through reactor and facilities design. Brochure from Walter Kidde Nuclear Laboratories, Inc.

335 Private Service Radiation Facility. Radiation Applications, Inc., announces opening of its Industrial Radiation Center in New York. Available on both service and contract basis.

EQUIPMENT

335 Clad Steel Equipment. 28-page bulletin describes properties of clad steel, fabrication procedures, equipment design considerations. R. E. Moyer, Inc.

DEVELOPMENTS OF THE MONTH (*Cont.*)



388 Tube-Type Cooler. An attached tube-type cooler featuring a new concept in dissipating heat from fine particle rotary kiln products is being manufactured by Allis Chalmers.

The improved cooler consists of a series of 3 to 5-ft. diameter and 15 to 20-ft. long tubes attached to the kiln ends parallel to the kiln shell to form a unit rotating integrally with the kiln. Within each tube is a series of spiral baffles which convey the material and serve as an intermediate in the transfer of heat.

In operation, the cooling air is induced into the tubes through the discharge openings and moves through the spiral baffles. The hot kiln product drops into the tubes at the other end, filling each tube to about one-half its volume. As the material moves uphill through the tubes it transfers its heat to the rotating spiral baffles.

This type of tube cooler is said to be especially suited for cooling fine and soft materials because there is no tumbling action or violent contact with the air stream to cause dust losses. Circle number 388 on Data Post Card for further information.

(Continued on page 68)

337 High Temperature Limit Control. Product of the Partlow Corporation, Model HL 15-10 mercury thermal control is designed for fast-acting precision control of critical temperatures. Bulletin with complete specifications.

338 Unit Steam Generator. Can be fired with light or heavy oil or with combination of gas and oil. Bulletin with performance chart and dimensions. Preferred Utilities Manufacturing Corp.

339 Direct Mounting Totally-Enclosed Motor. Accurate alignment is provided by a totally-enclosed, NEMA style "C" bracket with tapped holes for bolting from the driven equipment side. In ratings from 1 to 30 hp. Technical data available from U. S. Electrical Motors.

340 Portable Mix-Muller. Specifications, application data, and general arrangement drawings of 3 cu. ft. capacity unit. Comes equipped with dust-tight hood, 3 hp. motor and starter and 25 feet of power cable. Bulletin from Simpson Mix-Muller Division, National Engineering Co.

341 Industrial Blowers. Bulletin from General Blower Co. describes all types of air moving equipment. Stainless steel, neoprene coated, and chemically coated units available for corrosive conditions.

342 Nozzle Catalog. 30-page catalog with detailed engineering information and specifications of full line of industrial nozzles. Spray Engineering Co.

343 Sealless Plastic Pump. Sealless plastic pumps, manufactured by the Vanton Pump & Equipment Corp., have been used with complete success in the transferring of trivalent iron compounds in solution. Literature.

344 Forged Needle Valves. Hoke, Inc. introduces a new series of small, forged brass needle valves, angle and straight pattern, employing an O-ring stem seal. Complete information from manufacturer.

345 Sealless Centrifugal Pumps. No mechanical seal, no stuffing box. Lubrication automatically provided by fluid being pumped. Bulletin. Chempump Corp.

346 Electro-Pneumatic Positioner. Model "E" Electro-Pneumatic Positioner provides valve positioning which is directly proportional to DC signals received. No transducer required, full 100 lb./sq.in. plant air supply can be used. Bulletin from Conoflow Corporation.

347 Indicating Pneumatic Controller Data. Temperature ranges between 0 and 1,000°F. and pressure ranges from 0 to 1,000 lb./sq.in. All technical details in bulletin from Minneapolis-Honeywell Regulator Co.

348 Venturi Tube Information. Design features, dimensional data, capacity tables, recovery tables in new bulletin offered by Builders-Providence, Inc.

349 Bronze Valves. Bulletin gives physical characteristics and construction details of line of solder end and silver-braze end

(Continued on page 68)

High Speed Reduction to Micron Sizes — No Attritional Heat!

An ideal Grinder for the production of Insecticide Compounds from DDT, Aldrin, Dieldrin, BHC, etc.

The increased surface area from this type of grinding means greater bulk, for better dispersion and wettability, requiring less amount of wetting agent.

ENGINEERING FLUID-JET GRINDING IN "PACKAGE UNITS"

. . . comes naturally to Sturtevant engineers — with their 75-year tradition of successful solving of dry-processing problems. If you want to accomplish the most effective grouping of a Micronizer* Grinding Machine with necessary compressor, feeder and dust-collector, it will pay you to investigate. Check the coupon on the right for more information.

My dry-process materials are

Desired capacity is

Name Title

Firm

Street

City Zone State

Sturtevant Micronizer* Grinding Machines Give Greater Finenesses than Tube or Roller Mills

Look at the record! 30 inch model reduced titanium dioxide to 1 micron and finer at solid feed rate of 2250 lbs. per hr. 24 inch model reduced DDT (50%) to 3.5 average microns — 1200-1400 lbs. per hr. 8 inch model reduced Procaine—Penicillin—to 5 to 20 microns—up to 20 lbs. per hr. Couldn't you use milling performances like these?

No moving parts. The particles grind each other. High-speed rotation and violent grinding impact of particles are caused by jets of compressed air or steam at angles to the periphery of the shallow grinding chamber. There are no problems of attritional heat. Centrifugal force keeps over-sized particles in the grinding zone. Cyclone action in the central section classifies and collects the fines for bagging.

Instant accessibility, easy cleaning. Micronizer* Grinding Machines come in seven sizes — each one constructed for quick accessibility and easy maintenance (typified by the "OPEN DOOR" design in other Sturtevant equipment). Grinding chambers range from the 2 in. laboratory size with ½ lb. per hr. capacity to the 30 in. size which handles up to 3000 lbs. per hr.

* Registered trademark of Sturtevant Mill Co.

STURTEVANT MILL COMPANY 135 Clayton Street, Boston 22, Mass.

Please send me your Micronizer* Bulletin ☐
Also bulletins on machines for:

☐ CRUSHING ☐ GRINDING ☐ PULVERIZING
☐ SEPARATING ☐ BLENDING ☐ MIXING
☐ SUPERFINE SELECTING ☐ GRANULATING ☐ CONVEYING

STURTEVANT

Dry Processing Equipment

The "OPEN DOOR" to *lower* operating costs over *more* years

CRUSHERS • GRINDERS • MICRON-GRINDERS • SEPARATORS
BLENDERS • GRANULATORS • CONVEYORS • ELEVATORS

EQUIPMENT (Cont.)

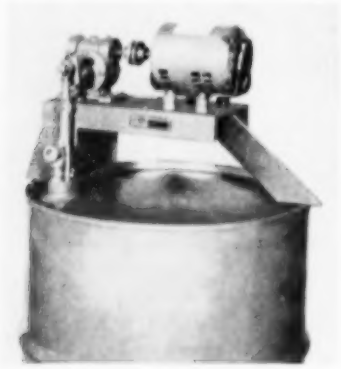
bronze valves in gate, globe, and check designs. R-P&C Valve Division, American Chain & Cable Co.

350 "Shear-Flow" Industrial Mixers. Counter-rotating impellers produce double-shearing action for perfect dispersion. Brochure from Gabb Special Products, Inc., illustrates size range, applications, specifications, and exclusive features.

DEVELOPMENTS OF THE MONTH (Cont.)

389 Controlled Volume Barrel Pump. The Milton Roy Barrel Pump is an inexpensive solution to the problem of accurately metering and pumping toxic or corrosive chemicals directly from barrels or drums to process.

The pump is simply set on the barrel head with the liquid end immersed in the toxic or corrosive fluid. A hose or pipe is connected to the discharge connection and the electrical plug connected to an outlet.



The pump then proceeds to empty the contents of the barrel at the preset controlled rate.

Empty barrels are easily and quickly replaced without additional piping. Corrosive or toxic fluids do not have to be transferred to elevated feeding tanks, and barrels can be located near the process. Repetitive pumping accuracy is about one per cent. Capacities are adjustable over the entire range of the pump through stroke length adjustment. Circle number 389 on Data Post Card for further information.

351 Continuous Flow Oxygen Analyzer. Employs colorimetric differential photometer method for continuous detection and accurate measurement of trace amounts of oxygen in gas streams. Bulletin from Consolidated Electrodynamics Corp.

352 Four Way Selector Valve. For accurate control of liquid flow to multiple spray manifolds or feed lines. Unit is supplied in ¼-in., ⅜-in., and ½-in. outlet connections. Information from Spraying Systems Co.

353 Induced Draft Cooling Towers. The Series 3 cooling tower, built by Fluor Products Co., is designed specifically for central station air conditioning and refrigeration systems in commercial and industrial plants. Bulletin.

354 Automatic Control Systems. New system, being introduced by the Rockwell Manufacturing Co., provides automatic switch control of all pumps and quantity control valves at the meter. Details in two-page bulletin.

355 Impervious Graphite Cascade Coolers. Catalog with diagrams, photographs, breakaway drawings, pressure drop calculations. Falls Industries, Inc.

356 Pneumatic Transmission System. Mechanism produces output air pressure that varies directly with flow through a Venturi tube, flow nozzle, or orifice plate. Bulletin from Simplex Valve & Meter Co.

357 Drying and Calcining Equipment. C. O. Bartlett & Snow Co. offer wide selection of research and pilot plant equipment for drying and calcining. Rental or purchase basis. Bulletin.

358 Controlled Volume Pump. For barrel head mounting. Pumps toxic or corrosive chemicals from 55-gallon barrels at pressures to 100 lb./sq.in. Adjustable capacities. Milton Roy Co.

359 Differential Pressure Sensing Unit. For precise measurement of differential pressure, flow, liquid level. Actuates indicators, recorders, transmitters, controllers, alarms. Barton Instrument Corp.

360 Self-contained Pump Seal. A compact unit for use in all types of jet water pumps, oil pumps and reduction units. Technical data from Garlock Packing Co.

361 Water Still Catalog. Barnstead Still & Demineralizer Co. offers 48-page catalog featuring "package" still and tank combinations.

362 Water Softening Equipment. Bulletin from the Permutit Co. gives technical details of organic and inorganic cation exchangers. Flow diagrams and specifications.

363 Laboratory Glass Catalog. Specifications and prices on line of "Lab-Crest" Pyrex glassware in 16-page catalog from Fischer & Porter Co.

364 Heavy-Duty Vessels and Equipment. Evaporators, vacuum pans, vacuum crystallizers, barometric condensers, vacuum filters, pressure filters, flakers, heat exchangers. Catalog from Goslin-Birmingham Manufacturing Co.

365 High-Speed Automatic Weighing Unit. The Glengarry two-station weighing unit handles wide variety of dry products over an adjustable range from 1 oz. to 5 lb. at speeds up to 40 units per minute. Bulletin from Glengarry Processes, Inc.

366 Continuous Digester for Pulp Mills. 8-page bulletin from the Pandia Division, Black-Clawson Co., describes and illustrates the "Chemi-Pulper." Many photos and technical drawings.

○ **CIRCLE** *your Data Service requests on the handy postcard on page 62 to*

▶ **GET** *up-to-the-minute catalogs, data sheets and bulletins on new chemical products, processes and equipment.*

367 Stainless Steel Liquid Meter. All wetted parts of stainless or corrosion-resistant non-metallics. Capacity from 20 to 100 gal./min. for most liquids. Neptune Meter Co.

368 Pressure and Differential Pressure Transmitters. "Null-balance-vector" principle permits greater compactness, reduces weight, permits easy change of range. Republic Flow Meters Co.

369 Precipitator Automation System. Eight-page bulletin with comparative charts gives technical details of new Research-Cottrell system. Bulletin.

370 Water Demineralization System. Penfield T-20, SR-1 System purifies water at point of use, at rates up to 40 gal./hr. All wetted parts of plastic construction. Penfield Manufacturing Co.

371 Radioactivity Instrument Catalog. Nuclear-Chicago Corp. offers 64-page catalog on radioactivity measuring instruments.

372 Control Systems. For precision measurement of pressure, differential pressure, flow, liquid level, temperature. Bulletin from Norwood Controls.

373 Continuous Carbon Monoxide Analyzers. Fully automatic, uninterrupted monitoring with minimum of supervision and maintenance. Bulletin from Mine Safety Appliances Co.

374 Multi-Louvre Dryer Book. Typical layouts, dimensional data and two-page psychrometric chart included in new 16-page book from Link-Belt Co.

375 pH Electrode Data Sheet. Engineering features and ordering instructions for dip-type immersion heads, continuous flow assemblies, and stainless steel mountings for pipeline pH measurements. Leeds & Northrup Co.

376 Technical Glassware Catalog. Current prices on 11,130 items of laboratory and scientific glassware. Kontes Glass Co.

377 Shredders, Grinders, Hashers. "Rigid hammer" type for reducing cork, pulp laps, wood chunks, rubber, citrus fruits, animal waste, bones, etc. Catalog from Jeffrey Manufacturing Co.

(Continued on page 70)

(Advertisement)

DIATOMITE FOR NON-FILTERAID USES

The versatility of diatomite products is exhibited to a remarkable degree in the non-filteraid uses. A comprehensive review of these applications would fill a book – hence, only a few highlights here.

CHEMICAL PROPERTIES. In many of its applications as a filler, diatomite is chosen because of its inertness. The calcined and flux calcined grades are outstanding in this respect. In most compositions these grades exhibit no solubility or adsorption whatsoever.

On the other hand, non-calcined (natural) diatomite is extremely reactive, particularly to alkalis. While no fundamental studies on specific reaction rates have been reported in the literature, considerable work has been conducted in industrial laboratories. These experiments have shown that natural diatomite is intermediate in reactivity between crystalline forms of silica and silica gel . . . this follows, of course, from the fact that natural diatomite is hydrous silica. Natural diatomite has tremendous surface area in proportion to weight; that from certain deposits has nitrogen adsorption surface areas exceeding 35 square meters per gram.

Thus, the diatomite industry provides a naturally-occurring mineral, in a variety of carefully controlled grades, priced in the range of other non-metallic minerals, which has the characteristics of manufactured products, such as silica gel, which cost several times as much.

Several uses have been made of this property of natural diatomite. For example, the high reactivity of diatomite to alkali has been used to control deleterious effects occurring when high alkali Portland cements are combined with reactive aggregates. No known naturally-occurring material reacts more rapidly with free alkali in cement slurries than does diatomite.

The insulation industry uses a large tonnage of diatomite to produce precast and other forms of thermal insulation by the reaction of hydrated lime and diatomite. This reaction, suitably catalyzed, is so fast that solid gels may be formed by heating to 175° F. for one minute. This permits rapid stripping from the molds to hold production costs in line.

Such fast reaction presents profitable possibilities in the production of other lightweight products in the range of 5-25 pounds per cubic foot.

Paul W. Leppla
Technical Director

Since Dicalite is essentially hydrated amorphous silica, it is inert . . . we've stressed the point for years. But it might be noted that there is an exception. The natural grades of Dicalite (meaning not calcined or flux-calcined) are extremely reactive with alkalis, a property made use of in the cement and insulating fields, and one which should be of value if you are concerned with certain types of lightweight materials, or processes requiring solid gels.

In the vast majority of applications, though, Dicalite 'filler' materials *are* completely inert, for all practical purposes. Furthermore, the unique characteristics given by the shape and structure of the diatomite particles provide several other desirable properties . . . great bulk in relation to weight, which gives bulking without significant increase in weight . . . tremendous surface area in relation to weight . . . extreme porosity, making Dicalite highly absorptive and also lending both heat-and-electrical resistance. These are the principal values of Dicalite filler materials; there are others.

Dicalite's engineering service will be glad to advise with you on your particular problem, or you may obtain additional information by writing:

Dependable GLC GREAT LAKES Dicalite® DIATOMACEOUS MATERIALS

DICALITE DIVISION · GREAT LAKES CARBON CORP. · 612 S. FLOWER ST. · LOS ANGELES 17

EQUIPMENT (Cont.)

378 Packaged Air Compressor. The "Channel-Flo" two-stage, 200 lb./sq.in. motor-compressor, product of Ingersoll-Rand Co., is available in 1½ and 2 horsepower sizes. Technical bulletin.

379 Water and Waste Treatment Catalog. Covers specific equipment in municipal, industrial sewage, and industrial waste treatment fields. 32 pages. Infilco, Inc.

380 Corrosive Fume Ventilation Equipment. 10-page report from Heil Process Equipment Corp. Recommended exhaust rates, procedures, air flow charts, types of systems. Equipment and applications.

381 Aluminum Bronze Pumps for Salt Water. Construction details, specifications, performance curves, dimensions. Goulds Pumps, Inc.

PRODUCTS ADVERTISED IN THIS ISSUE (Cont.)

59A Pump Catalog. Condensed catalog shows complete line of Aldrich direct flow pumps, especially suited to chemical process service. Aldrich Pump Co.

60A Fertilizer Plant Design. Fluor Corp. offers completely integrated services to the fertilizer industry—design, construction, and processes.

65A Heat Exchangers. Painstaking fabrication and testing procedures employed by the Patterson-Kelley Co. assure satisfactory performance.

67A Grinding Machines. Micronizer Grinding Machines, manufactured by the Sturtevant Mill Co., are available in seven sizes. Capacity up to 3,000 lb./hr.

69A Diatomite Filler. Literature from Dicalite Division, Great Lakes Carbon Corp., describes uses and applications of Dicalite filler materials.

71A Lithium Data Sheets. Technical data on lithium metal, metal dispersions, metal derivatives, and salts. Lithium Corp. of America.

73A Horizontal Filters. Bulletin from Industrial Filter & Pump Mfg. Co. gives complete technical details on line of horizontal filters.

74L Motorpump Catalog. Ingersoll-Rand Motorpumps operate in any position, present no alignment problem, need no baseplate or coupling. Complete bulletin.

75A Plant Design and Construction. Single responsibility contracts as offered by J. F. Pritchard & Co. are the key to a successful construction job.

76L Filtration Catalog. Specifications and technical data on line of filter presses. D. R. Sperry & Co.

77A Vinyl Resins. Complete line of vinyls engineered to your specific needs. Complete information from Chemical Sales Division, Firestone Plastics Co.

78A Magnesia Insulation. Unexcelled for temperatures up to 600° F. Technical data on Johns-Manville 85% magnesia insulation.

82L Corrosion-Resistant Linings and Brickwork. Cements, linings, coatings, rigid plastics. Engineering and construction services. Bulletin from Atlas Mineral Products Co.

83A Low-Nickel Stainless Steels. Data sheets from Crucible Steel Co. of America give properties of Rezistal type 201 and 202.

85A Anode Connections. For mercury cells. Great Lakes Carbon Corp.

86L Spray Drying System. Uniform bulk density and particle size with low power consumption. Bulletin from Nichols Engineering & Research Corp. describes "Nerco-Niro" system.

87A Inert Gas Generators. Easy to operate, start quickly, give continuous output around the clock. Bulletin from C. M. Kemp Mfg. Co.

88L Entrainment Manual. New, illustrated 16-page "Schuylernit" Entrainment Manual shows how to get clean, positive liquid/vapor separation in vacuum and flash towers, absorbers, scrubbers, evaporators, & distillation equipment. Schuyler Manufacturing Corp.

89A Lummus-Designed Beryllium Plant. New plant, designed by the Lummus Co. for Beryllium Corp., scheduled to start up in August.

90L Alloy Castings. Static high alloy and centrifugal castings. Duraloy Co.

91A Research Facilities. Research activities of Curtiss-Wright Corp. extend into electronics, atomic power, aviation, metallurgy, plastics, ultrasonics.

93A Drying Services. Proctor & Schwartz, Inc. offer integrated service for the economical solution of any drying problem.

94L Eight-speed Viscometer. Easily-operated, portable instrument provides precise measurements directly in centipoises. Brookfield Engineering Laboratories, Inc.

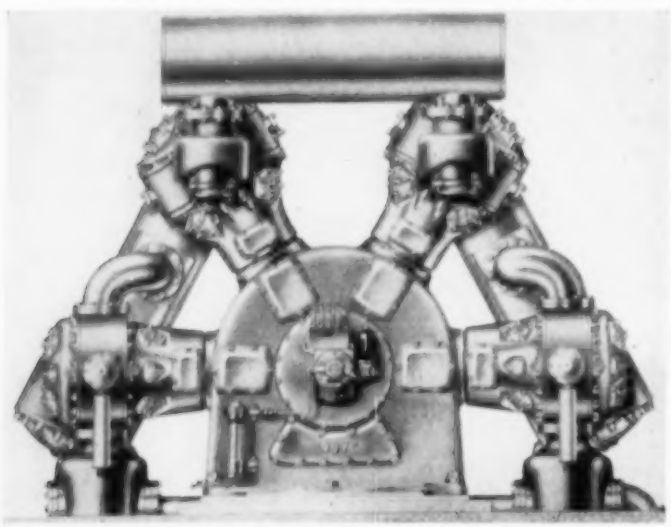
95A Batch and Continuous Kilns. 3 types for wide variety of pre-heating, processing and disposal operations. Bartlett-Snow.

96L Venting Manual. Describes complete line of storage tank safety equipment. Protectoseal Co.

97A Horizontal Filters. High capacity per unit area, multi-stage counter-current wash. Bulletin from Dorr-Oliver, Inc.

98L Woven Wire Belts. In any size, mesh or weave, in any metal or alloy. 130-page reference manual from Cambridge Wire Cloth Co.

(Continued on page 72)



DEVELOPMENTS OF THE MONTH (Cont.)

390 Heavy-Duty Industrial Air Compressor. According to the manufacturer, the Joy Manufacturing Co., the WN-224 is the largest package-type compressor available. Output at 80 to 125 lb./sq.in. gauge is rated from 2,418 to 6,048 cu.ft./min., depending on motor horsepower. The unit is a four-cylinder, double-acting, water-cooled machine of semi-radial design, achieving final pressure in two stages.

Three standard single models and three "Twin Unit" models are available. Drive may be by electric motor, diesel engine, steam turbine, or turbo-electric combinations.

Detailed specifications are available from the manufacturer. Circle number 390 on Data Post Card for further information.

(Continued on page 72)

LITHIUM

HIGH ENERGY

fuel for thought

THE fuel propellant of the future may prove to be an inorganic material, with metallic properties, capable of releasing tremendous heat burning capacity. Such an inorganometallic will likely contain a compound of *lithium*. For *lithium* offers uniquely valuable properties . . . properties that aid in contributing an unusually high power-to-weight ratio so necessary for military missiles and rockets.

Lithium, for example, combines low density with high heat of combustion to give a much sought after ratio of extraordinary chemical energy per unit of weight. On this score alone it proves of inestimable value.

Will these properties improve your product?

. . . low density
. . . high heat capacity
. . . high heat of fusion
. . . chemically reactive
. . . low melting point
. . . high flash point
. . . easily cut with a knife
. . . ductile, can be extruded and rolled
. . . readily melted or cast
. . . lighter than magnesium or aluminum
. . . can be dispersed in suitable media

Consult our PR&D department on your use-research problems. Up-to-date Product Data Sheets on lithium metal, metal dispersions, metal derivatives and salts are yours for the asking.

. . . trends ahead in industrial applications for lithium

LITHIUM CORPORATION OF AMERICA, INC.
2540 RAND TOWER, MINNEAPOLIS 2, MINN.

PROCESSORS OF LITHIUM METAL • METAL DISPERSIONS • METAL DERIVATIVES: Amide • Hydride • Nitride • SALTS: Bromide • Carbonate • Chloride • Hydroxide • SPECIAL COMPOUNDS: Aluminate • Borate • Borosilicate • Cobaltite • Manganite • Molybdate • Silicate • Titanate • Zirconate • Zirconium Silicate

BRANCH SALES OFFICES: New York • Pittsburgh • Chicago • MINES: Keystone, Custer, Hill City, South Dakota • Bessemer City, North Carolina • Cat Lake, Manitoba • Amos Area, Quebec • PLANTS: St. Louis Park, Minnesota • Bessemer City, North Carolina • RESEARCH LABORATORY: St. Louis Park, Minn.

PRODUCTS ADVERTISED IN THIS ISSUE (*Cont.*)

99A Nitrogen Gas Generator. Complete packaged unit made by Gas Atmospheres, Inc.

101A Heat Transfer Medium. For process heating applications at temperatures from 350 to 750° F. Information on Dowtherm from Dow Chemical Co.

102L Disc-Roll Mill. Roller-type mill with two adjustable, pneumatically loaded rolls for grinding material on horizontal rotating disc or table. Bulletin from Hardinge Co.

103A Heat Exchangers. Heating surfaces scientifically arranged to increase heat transfer and to save floor space. Alberger Heater Division, Adsco Industries, Inc.

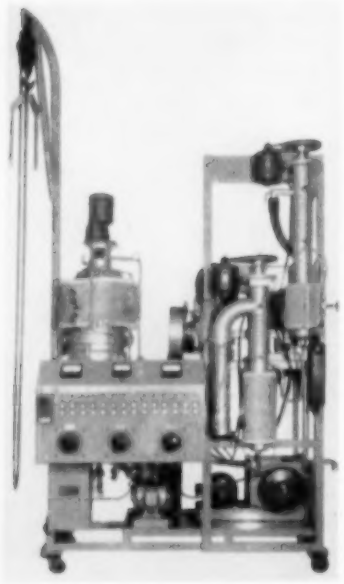
104TL Scale Feeders. Merchen Scale Feeders have feed rates from 3 to 3,000 pounds per minute, require no adjustment for density changes. Wallace & Tiernan, Inc.

104BL Chlorinators and Chemical Feeders. For slime elimination, water treatment and purification, industrial waste and sewage treatment. Wallace & Tiernan, Inc.

105A Sulfur Used in Propellents. "Thiokol" synthetic rubber, containing large percentage of sulfur, finds use in solid fuels for rockets. Texas Gulf Sulphur Co.

DEVELOPMENTS OF THE MONTH (*Cont.*)

391 Twelve-inch Pilot Still. Still is shipped as a self-contained package unit needing only power and water outlets for immediate operation. It features a film-type preheater-degasser, and has a capacity of up to 200 pounds per hour. It is self-cleaning, of stainless steel construction throughout, and may be used for production purposes within its capacity range. Circle 391 on Data Post Card for further information.



106L Centrifugal Pump Bulletin. From 1/8 to 3/4 horsepower, capacities up to 70 gal./min., pressures to 65 lb./sq.in. Eastern Industries, Inc.

107A Stainless Steel Circles. Small and medium size circles, often available from stock, save about 25% transportation costs over squares. Large circles cut to order. G. O. Carlson, Inc.

109A Fire Pumps. All sizes for all industrial and municipal requirements. Details from Fairbanks-Morse.

110L Centrifugal Blowers. Uniform delivery of air or gas without use of receivers. Bulletin with complete specifications from Roots-Connersville Blower.

111R Mist Eliminators. Metex mist eliminators assure complete liquid-vapor separation in evaporators, packed columns, knock-out drums, etc. Metal Textile Corp. Bulletin.

112L Filter Papers. Test run samples furnished without obligation. Eaton-Dikeman Co.

113R Automatic Weigher. The Autoweighton system using patented Thayer Plate Leverage System gives guaranteed accuracy. Thayer Scale Corp.

114L Steam-Jet Evactor Units. Absolute pressures down to 50 microns Hg abs. Croll-Reynolds Co.

114R Mixing and Grinding Equipment. Double-arm kneaders, three-roller mills, change-tank mixers. Complete information on these and other types of similar equipment. Charles Ross & Son Co.

115TR Processed Fullers Earth. Meshes from 2/4 to 200/up. Special meshes also available. Floridin Co.

116B Welded Chemical Vessels. In all sizes and types in carbon or stainless steels, aluminum, or special alloys. Bulletin from R. D. Cole Manufacturing Co.

117TL Drum Reconditioning Machines. Gilco Model DDM-53U removes dents from 55, 30, and 15 gal. closed steel drums. Details from L. M. Gilbert Co.

117BL Gear Pumps. Bulletin from Schutte and Koerting Co. describes complete line of gear pumps and scope of engineering services available.

117R Chemical Process Dryers. Continuous or batch for laboratory or production line. C. G. Sargent's Sons Corp.

118L Tower Packings. Sizes, weights, surface area of various types described in bulletin from Maurice A. Knight.

118BR Heat Exchange and Process Equipment. Condensers, evaporators, reactors, pressure vessels, heat exchangers, etc. Bulletin from Manning & Lewis Engineering Co.

119TR Grinding Equipment. Attrition mills, breakers, crushers, hammer mills, granulators and related equipment. The Bauer Bros. Co. Bulletin.

119BR Spray Nozzle Catalog. All types for washing, cooling, processing, humidifying, dehydrating, etc. Binks Manufacturing Co.

120L Process Equipment. Complete catalog showing facilities and services of Goslin-Birmingham Manufacturing Co.

120TR Jobs for Designers. Process, equipment, mechanical, instrument designers wanted by DuPont. Many benefits.

120BR Thermo-Panel Coils. Can replace pipe coils in many process applications with increased efficiency. Dean Products, Inc.

121TR Pyrometer Indicator. The MiniMite, null balance, potentiometer type, has 23½ inch double scale. Bulletin from Thermo Electric Co.

121BR Liquid Filler. Low-cost stainless steel unit combines compactness, simplicity, speed, and accuracy. Arthur Colton Co.

124TL Plastic Construction Material. "Lamicor" combines unusual chemical, electrical, mechanical, and structural properties. Available in sheets, angles, beams, channels, or formed shapes. Strick Plastics Corp.

124BL Spray Nozzle Data. Complete catalog from the Spraying Systems Co.

125R Aero Heat Exchanger. Niagara Sectional Aero Heat Exchanger saves 95% of cooling water cost. Bulletin from Niagara Blower Co.

127TL Heavy-Duty Steam Coils. Tilted feature assures drainage of condensate when installed in any position. Details from Rempe Co.

127BL Pyrex Sight Glasses. True circles, precision-ground from heat-resistant polished plate glass. Swift Glass Division, Swift Lubricator Co.

127R Non-Lubricated Plug Valves. Models in broad range of materials—also with Teflon-faced plugs. DeZurik Corp.

128L Polyethylene Lab Ware. Brochure describes complete line manufactured by Ace Glass, Inc.

129L Nickel Alloy Equipment. Misco Fabricators, Inc. specializes in the fabrication of process equipment in nickel alloys.

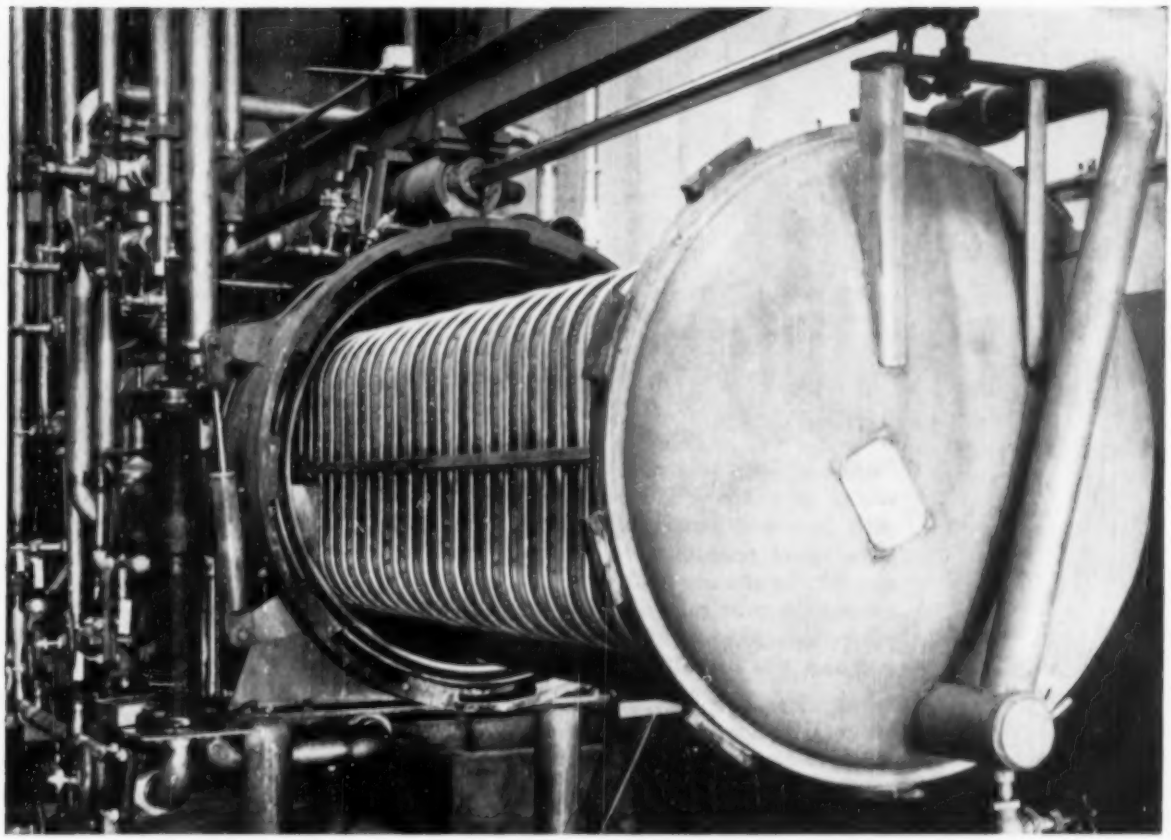
129R Silicone Defoamer. Free sample of Antifoam B furnished on request. Dow Corning Corp.

138BL Batch Mixers. In capacities from 100 to 8,000 lb. per batch. Technical literature from H. C. Davis Sons' Mill Machinery Co.

139R pH and Chlorine Control Handbook. Gives theory and application of pH control. Describes full line of equipment made by W. A. Taylor & Co.

IBC Engineering and Construction Services. Ralph M. Parsons Co. lists some of the important clients whom they have served during the past year.

OBC Mixers. Research department of Mixing Equipment Co. is always glad to cooperate in work leading toward more efficient fluid mixing.



How Industrial Filter gets the profit out of fruit juice "Tank Bottoms"

The trouble with natural fluids is their variability—not only differences in batches but their tendency to stratify in storage. The latter was the problem in handling fruit juice at an eastern plant—the bottom layers in tanks were heavy with particles of valuable crystallized sugar that were lost in clarification. With their new Industrial filter system they extract the sugar at a handsome profit that paid for the system in a few months.

Industrial's Horizontal Filter clarifies juice and recovers sugar in one continuous operation. The filter is first pre-coated and clarification established. The juice is then flowing from the storage tank thru the filter and on to the processing lines. After the filter leaves have built up the maximum coating, the filter is blown dry and a mixture of water and air is injected under pressure. The water dissolves the fruit sugar and is continuously filtered out until the sugar content drops below 2% of soluble solids. The filter is then emptied, opened and the cake is recovered. Most Industrial Horizontal Filters have mechanical shakers that drop the cake directly into a truck for fast clean recovery of solids.

Industrial engineered filtration is not only cost saving... it's downright profitable! Besides the lucrative recovery of solids, this up-to-date unit operates at a high filtration rate, it requires only one man to run it, it eliminates the buying and washing of filter press cloths, and its all-around efficiency requires less filter aid.

Industrial produces all types of filters . . . Horizontal, Vertical, Tubular, Hydra Shoe . . . and can *recommend, without partiality, a filter most suitable to your particular requirements.* A great variety of cost-saving optional features are available and almost all Industrial Filters are *adaptable to complete automation.* Intelligently selected, soundly engineered filters can pay for themselves in a surprisingly short time.

Write for Bulletin NH-122, a complete description of Industrial's Horizontal Filters.

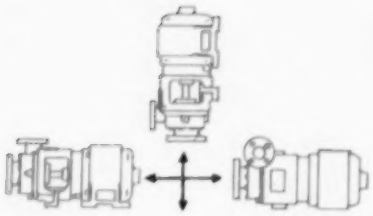
Industrial

INDUSTRIAL

FILTER & PUMP MFG. COMPANY

5910 OGDEN AVENUE • CHICAGO 50, ILL.

you get



versatility too

Plant engineers and operating personnel who have had experience with Ingersoll-Rand Motorpumps have found ease of installation of special importance and an extra advantage over and above Motorpump efficiency, dependability, stamina and low overall maintenance.

Motorpumps are compact to save space, they operate in any position, they present no alignment problem, need no baseplate or coupling.

These are important points to consider when you want a pump. See your local Ingersoll-Rand representative or write for the complete bulletin on Motorpumps.

Ingersoll-Rand

11 Broadway, New York 4, N.Y.

MOTORPUMP sizes ¼ to 75 hp / capacities to 2800 gpm / heads to 650 ft

INDUSTRIAL NEWS

A $2 million petrochemical plant that consists of a Udex extraction unit will be built by the Vickers Petroleum Co. at its Potwin, Kan., refinery. Designed by Universal Oil Products Co. and to be built by Procon, Inc., the new plant will be the first petrochemical plant built by an oil company in Kansas, will manufacture benzene, toluene, xylene, and nine to eleven carbon chain aromatics. □

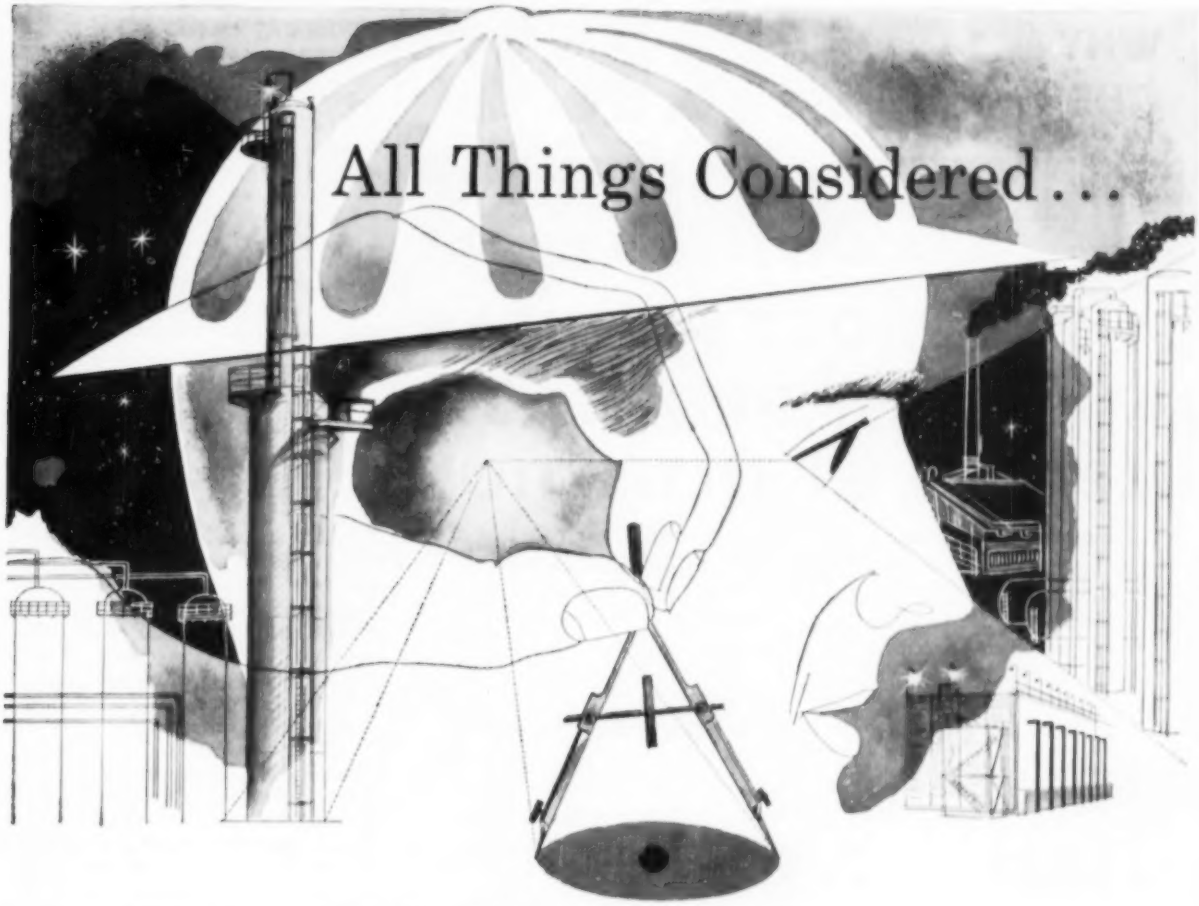
Three sites in San Diego County, Cal., are now under consideration for a proposed 20,000 barrel-a-day refinery to be built by Cal-Mex Oil and Refining Co. Contract for design, procurement, and construction has been awarded to The Ralph M. Parsons Company of Los Angeles. On-stream date: early 1959. □

Dow Chemical has purchased a 50% interest in Sales y Alcalis, S.A., a Mexican chemical company situated near Coatzacoalcos. Future manufacturing operations of the Mexican firm involve caustic soda and other alkali derivatives, chlorine, and related products. □

An engineering and construction contract for the modernization of Goodrich-Gulf Chemicals' synthetic rubber plant at Institute, W. Va., has been awarded to the Girdler Co. of Louisville. Girdler will convert one of the three production lines to a cold rubber process. □

Initial production of carbon bisulfide from expanded facilities at Cornwall Chemical's Cornwall, Ontario, plant has added about 60% to the plant's previous capacity. Continued growth in production of viscose rayon and transparent regenerated cellulose film account for most of the increase in demand, but Cornwall also announces that new markets are opening, and that the company plans to use its own carbon bisulfide to manufacture carbon tetrachloride very soon. □

A packaged Girbotol plant to produce 1,500 barrels per day of a propane-butane liquid hydrocarbon mixture by removing 10,000 pounds of hydrogen sulfide, will be built by The Girdler Co. for Delta Refining Co. of Memphis, Tenn. A 20% water solution of diethanolamine will be employed in a liquid phase absorber to scrub the hydrogen sulfide from the hydrocarbon. The amine solution will be regenerated in a conventional reactivator for subsequent reuse in the absorber. □



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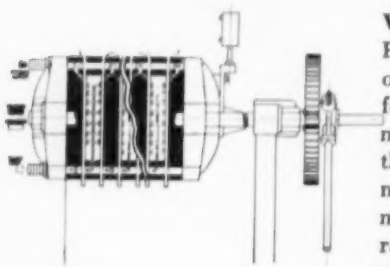

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INDUSTRIAL NEWS

A $5 million sodium chlorate plant will be built at Aberdeen, Miss., by American Potash & Chemical Corp. Initial production will be at the rate of 15,000 tons a year, with provision for expansion. Completion is scheduled for mid-1958. ☐

Plans are in the works for a 50 million pound a year vinyl chloride monomer plant. Diamond Alkali is the company involved, location will be Diamond's Deer Park Plant at Houston, Tex., design and engineering is in the hands of Scientific Design Co., and actual construction will be done by Brown & Root of Houston. Target date: early 1958. ☐

Special polyethers for use in manufacture of polyurethane foam plastics have been developed by Wyandotte Chemicals. Three pluronic types have already been field tested, and have been found, according to Wyandotte, to offer lower manufacturing cost and improved life for products embodying polyurethanes. ☐

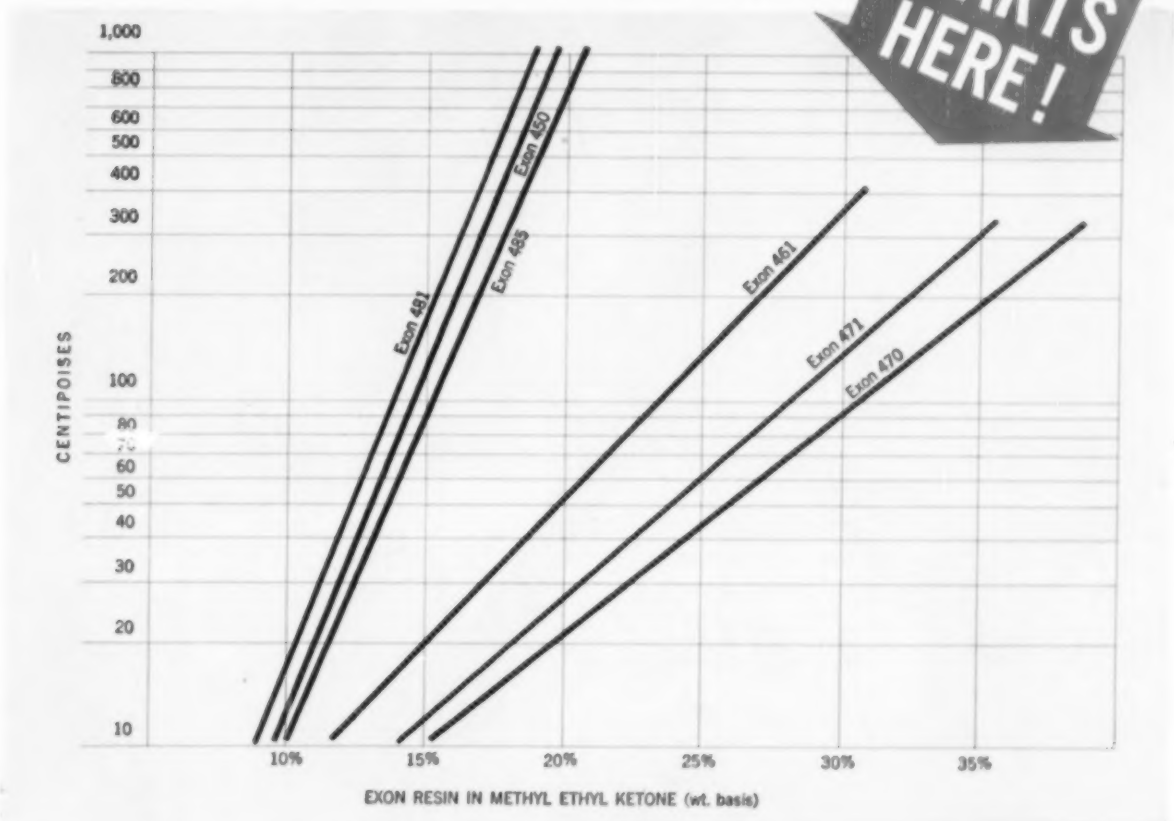
Construction is now in progress on a new plant building for the Griscom-Russell Company in Massillon, O. Special housing is required to provide the unusual sanitary, temperature, and security conditions needed for development and fabrication of the company's heat exchangers destined for A.E.C. ☐

Design, engineering and construction of a new catalytic reformer at U. S. Oil & Refining Co.'s Tacoma, Wash., refinery will be done by Holmes & Narver, Inc., Los Angeles, Cal. To cost some $750,000, the new unit will have a charge capacity of from 2,500 to 3,000 barrels daily. Completion is slated for May, 1957, unit is being designed under license from Houdry Process Corp., Philadelphia, Pa. ☐

Merger of Heyden Chemical and Newport Industries is now complete. Heyden has acquired the assets of Newport and changed its name to Heyden Newport Chemical Corp. The companies had total sales of $46.5 million in 1955, $34.5 million for first nine months of 1956. Newport will continue under its present management as Newport Industries Co., a division of Heyden Newport. ☐

A 50 million pound a year unit to manufacture fluorocarbons will be built by Carbide and Carbon Chemicals at the company's Institute, W. Va. plant. ☐

SUCCESS IN COATINGS STARTS HERE!



EXON CHARTS SOLUBILITIES to help you choose the resin with properties Pin-Pointed to your special needs!

EXON 450 Ideal for strip coatings. Good solubility, tensile strength and durability.

EXON 461 A unique fluorine-containing resin combining high solubility, unusual chemical resistance, heat stability and weatherability.

EXON 470 Excellent adhesion to metals, alkyd and vinyl surfaces. Compatible with wide range of drying oils, alkyds, phenolics, melamines. High solubility in inexpensive solvents.

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EXON 485 For superior strip coatings. Lower viscosity makes application easier and shelf-life better. Good clarity.

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THE special nature of Exon resins — "Pin-Pointed Properties" to supply specific answers to special needs — is particularly desirable in the manufacture of coatings.

Because products and processes vary, Firestone Exon has engineered 6 solution resins to help you formulate a successful coating. Each resin differs in properties, such as the solubility factor charted above, to suit various applications.

One property in common: superior quality of performance with the resultant production speed and savings which have made Firestone Exon industry's No. 1 source of specifically engineered vinyl resins.

We suggest you keep this chart handy—to help you put your finger on the right resin for *you* — at a glance.

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CHEMICAL PROGRESS MEN APRIL 8-12

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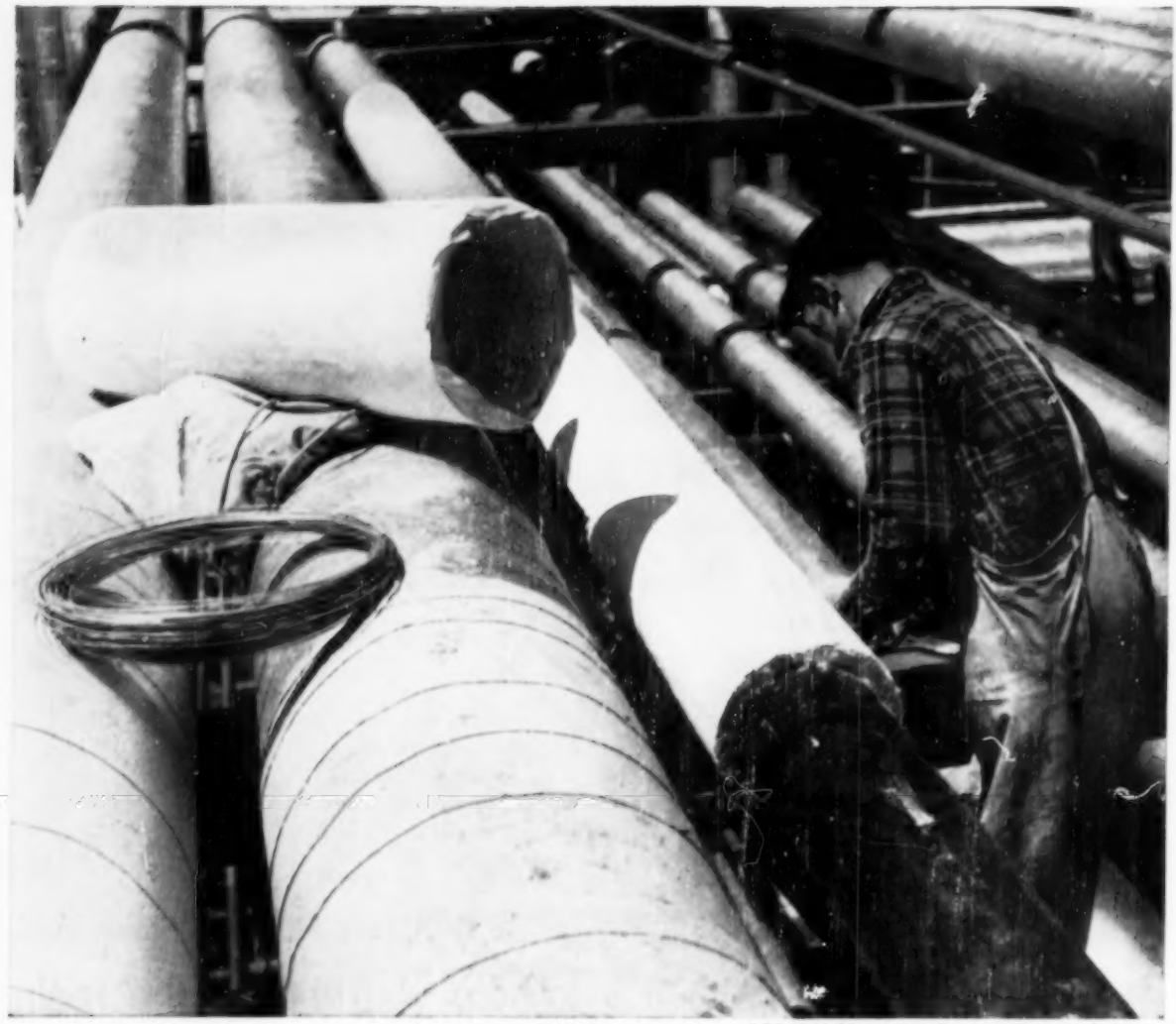

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Seattle from Queen Anne Hill; Mt. Rainier in background.

Pacific Northwest—a center of the chemical industry—is the setting for the A.I.Ch.E. June meeting, promises

MAJOR TECHNICAL PROGRAM AT SEATTLE

Marshall T. Ramstad | Pennsylvania Salt Manufacturing Co. of Washington, Tacoma, Washington

The swimmers, fishermen, and just plain sight-seeing vacationers who head for Seattle and A.I.Ch.E.'s June 9-12 National Meeting all have one thing in common—they are engineers. That means the vacation is important but the technical program is the main thing.

A glance at the map on the next page should be enough to convince the engineer that this is one of the major chemical industry centers of the nation.

PLANT TRIPS

This is a chemical industry center, and you won't want to miss these trips:

MONDAY, June 10	
U. S. Plywood Corp.	9:30 A.M.
Borden Co., Chemical Div.	9:30 A.M.
Boeing Airplane Co.	1:30 P.M.
TUESDAY, June 11	
Weyerhaeuser Timber Co.	9:00 A.M.
Hooker Electrochemical	9:00 A.M.
American-Marietta	1:00 P.M.
WEDNESDAY, June 12	
American Smelting & Refining	9:00 A.M.
Kaiser Aluminum and Chemical	1:30 P.M.

While a great deal of the booming chemical industry in the area is related directly to the pulp and paper industry, an oil refinery complex has grown up, is still growing with the latest entry being the Texas Co.'s 40,000 barrel a day refinery at Anacortes. The coming of natural gas into the region last year has also started a chemical processing expansion, will affect the area strongly in near future. Once heavy in ammonia, for both pulp and fertilizer, there is now an ammonia comeback underway based mainly on its growing use in pulping. The day has passed when the area had unlimited supplies of cheap power, but with the untapped potential of Alaska and British Columbia, and boosts in local power supply, the electrochemical industry is still one of the biggest, will probably grow larger in the area. Main products are caustic, chlorine, hydrogen peroxide, silicon carbide, calcium carbide, etc. Also big in the Northwest: explosives, nitric, acetylene, oxygen, nitrogen.

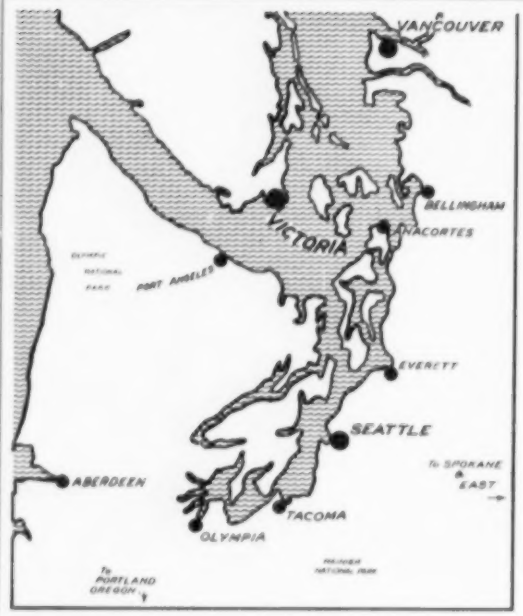
As befits such a locale, the technical program is going to have some extra-special meat in it.

Pulp and Paper

Chemical center and probably *the* major pulp and paper industry center, Seattle could not have a chemical engineer's meeting without a close look at Chemical Engineering in the Pulp and Paper Industry. Latest new plant, and first in Alaska, is the Ketchikan $60 million magnesia-base sulfite pulp mill. It's the first of its type, is intended for rayon pulp, with corrosion a basic problem.

Recent expansions in capacity have been made largely by the kraft process, recovery of chemicals is important in

Air view of the impressive University of Washington campus at Seattle.



SEATTLE
Air Reduction
American Marietta
Associated Lead & Zinc
Borden Co., Chemical Div.
Linde Air Prod. (Carbide)
Monsanto, Plastics Div.
National Cylinder Gas
Reichhold Chemicals
Seattle Gas Co.
Stansbury Chemical
Western Oxygen, Inc.

TACOMA
American Smelt. & Ref.
Columbia Powder (Olin)
DuPont
General Chemical Co.
Hooker Electrochemical
Kaiser Alum. & Chemical
Pacific Powder Co.
Pennsalt Chemicals
Philadelphia Quartz
Purex Corp.
Reichhold Chemical
St. Regis Paper
Stauffer Chemical
West Tacoma Newsprint

VANCOUVER, B. C.
Hooker Electrochemical
Electric Reduction

EVERETT
Weyerhaeuser Timber
Scott Paper Co.

BELLINGHAM
Puget Sound Pulp & Timber

PORTLAND, ORE. & VANCOUVER, WASH.
Air Reduction
Becco Chemical Div. (Allied)
Carborundum Co.
Electro Metallurgical (Carbide)
General Chemical Div. (Allied)
Hercules Powder
Linde Air Prod. (Carbide)
Pacific Carbide & Alloys
Pennsalt Chemicals
Stauffer Chemical

RICHLAND & HEDGES
General Chemical Div. (Allied)
General Electric Hanford Atomic Products Operation

this process, the design factors involved are detailed.

Continuous pulping! Here is a subject the entire industry is studying. Great strides have been made in the last five years, chemical engineers will be brought up to date, shown where the chemical engineer can best get into the field.

By-product utilization is the key to the growth of the industry. That's what a lot of experts say, and the chemical engineer is the key to by-products. One major possibility is dimethyl sulfide.

As symposium chairman McCarthy puts it, "The special goal of the symposium is to emphasize the role of the chemical engineer in the operations and progress of the pulp and paper industry." It's a big field for the chemical engineer.

Data and Calculations

Chemical engineers are alert to new data, new procedures, says chairman Edmister. It's important enough to rate two sessions—two big sessions. Vapor-liquid K values will be explored, the ever-present problem of distillation calculations will get some new treatment. Computer applications, detailed practical work, are in for a thorough study.

Key words here are: new and combined. New data, new procedures for finding, using, and computing the data and the combination of new experimental data with the powerful tool of the computer to get engineering work done.

SEATTLE TECHNICAL PROGRAM

MONDAY, JUNE 10

GENERAL PAPERS I, F. W. Woodfield, General Electric Co., Richland, Wash., presiding.

Approximate Operational Calculus in Chemical Engineering, S. W. Churchill, Univ. of Mich., Ann Arbor, Mich.

Approximations are suggested to extend the usefulness of operational calculus in solving boundary value problems of interest to the chemical engineer. Use of computers considered.

Pneumatic Thermometer and Hygrometer, C. L. Coldren and E. W. Comings, Univ. of Ill., Urbana, Ill.

New and unique instrument for measuring the air temperature and humidity in a hot turbulent stream within a spray. How it was developed, how you can do it.

Impact of Natural Gas on the Economy of the Pacific Northwest, C. A. Trexel, Jr., Stanford Res. Inst., Menlo Park, Cal.

Analysis of plant site opportunities opened by the advent of natural gas in the region in 1956.

An Experimental Spray Dryer for Product Development Studies, E. J. Crosby and W. R. Marshall, Jr., Univ. of Wisc. Madison, Wisc.

Properties of spray dried materials obtained with a specially designed experimental spray dryer, including effects of certain variables on the relationship between particle size distribution of the product and the original drop size distribution of the spray.

The Effect of Drying Conditions on the Properties of Spray Dried Particles, E. J. Crosby and W. R. Marshall, Jr., Univ. of Wisc., Madison, Wisc.

The influence of air temperature, feed concentration and particle size on the properties of dry particle density, dry particle size, and bulk density.

Heat and Momentum Transfer in the Flow of Gases through Packed Beds, M. B. Glaser and G. Thodos, Northwestern Tech. Inst., Evanston, Ill.

Flow of gases through solid metallic packings. Gas film heat transfer data under steady state conditions and in the absence of mass transfer effects.

ELECTROCHEMICAL ENGINEERING (Simultaneous with General Papers I), J. Schulein, Ore. State, Corvallis, Ore., presiding.

Co-Deposition of Tin-Nickel Plate from Non-Aqueous Solvents, I. T. Campbell and R. Abel, U. S. Bur. of Mines, Albany, Ore.

Bright plate was obtained in co-deposition of tin-nickel plate (65% tin, 35% nickel) from solvents such as formamide, acetamide, ethylene glycol, and triethanolamine. The variables are discussed.

Metallic Borides and Silicides by Fused Salt Electrolysis, H. T. Fullam and R. W. Moulton, Univ. of Wash., Seattle, Wash.

Electrolytic deposition of borides and silicides of titanium from fused salt baths. Zirconium, molybdenum, and chromium compounds also considered.

Some Industrial Use Aspects of U. S. Pacific Northwest and Alaska Power Potentials, I. Bloch and J. H. Davidson, Ivan Bloch & Assoc. of North Pacific Consultants, Portland, Ore.

Plant site analysis of Northwest based on hydroelectric power potential still untapped in Canada and Alaska.

Horizontal and Vertical Mercury Cell Development in Europe and the United States, H. A. Sommers, Food Machinery and Chemical Corp., New York, N. Y.

The mercury cell as used in many countries. Trend here and abroad is to fewer cells of larger capacity per cell.

Operation and Maintenance of I.T.E. Mechanical Rectifiers, T. N. Cootsona and A. M. Bretschger, Food Machinery and Chemical Corp., Vancouver, Wash.

Experience in use of mechanical rectifiers as compared to mercury-arc rectifiers in the production of ammonium persulfate. Includes the economics.

General Papers, Hanford, Nuclear & Electrochemical

Third General Paper session is all Hanford. There has been a lot of nuclear and basic engineering work at Hanford the chemical engineer should know about whether he is with a company eyeing the nuclear field or not. It's just been declassified. The other two General Paper sessions range over a wide field. A new measuring instrument for temperature and humidity, new calculation methods, plant site opportunities in the growing Pacific Northwest, unique experimental drying equipment and methods, kinetic reaction rate studies, radioactive tracing techniques, etc.

Is there a new field of nuclear engineering or isn't there? Are we going to have special nuclear engineers, or are chemical engineering and the other major disciplines to do the job? As an engineer are you going to get into the nuclear field? How do you get the training? AEC is working on the problem, industry has perhaps the biggest stake and it is going to have to work with the colleges. Some companies are already acting and how they are doing it will be told at Seattle.

The Pacific Northwest is an electrochemical center. Plant site locations, power availability, will be analyzed. Economics, and specific operational problems such as co-deposition, non-aqueous solvents, the trends in mercury-cell operation, electrolytic production of titantium boride and silicide, will give the chemical engineer a lot to think about.

Filtration

F. M. Tiller will have another of his own papers challenging long accepted concepts in the field. A new test leaf will be unveiled for studying pre-coat filtration, never possible before. Methods for predicting resistance and the most economical filtration areas and operating conditions, detailed study of characteristics and economic advantages of non-woven filter media, will all be presented. Principles of wide general application will give the chemical engineer a lot of valuable material to take home.

KLAHOWYA, TILLICUM!

For The Ladies

The committee has a big program for the ladies' entertainment while husband-engineer is deep in the technical program. After the regular morning coffee hours for getting acquainted, there will be a water tour around Seattle on Monday, a luncheon and fashion show on Monday afternoon, a bus tour of Seattle on Tuesday morning, and the big Indian Salmon Bake on Tuesday afternoon. It's an all-afternoon affair with a boat trip, dancing and swimming.

CHEMICAL ENGINEERING IN THE PULP AND PAPER INDUSTRY, James Hull, Crown Zellerbach Corp., Camas, Wash., and J. L. McCarthy, Univ. of Wash., Seattle, Wash., presiding.

Application of Stainless Steels for Combatting Corrosion in a Sulfite Pulp Mill, J. Kolberg, Ketchikan Pulp Co., Ketchikan, Alaska.

Where stainless steels can be used in paper mills to combat corrosive effects, including methods of preventing various forms of corrosion in the stainless itself.

Continuous Production of Wood Cellulose Pulp, L. A. Lundberg, A. H. Lundberg, Inc., Seattle, Wash.

Design, operating and economic factors to be considered, especially relative to the common batch process and the shorter cycle batch process.

Economic Planning of Kraft Mill Evaporators, R. E. Florine and W. G. Dedert, Swenson Evaporator Co., Harvey, Ill.

Because Kraft mill evaporators are usually specified on the basis of immediate capacity, future expansion can become very expensive. By advance planning in the original installation additional capacity can be made available at minimum cost. Relative before and after costs are given.

Dimethyl Sulfide Production From Kraft Pulp Mill Black Liquor, W. G. Meyer and J. G. Coma, Crown Zellerbach Corp., Camas, Wash.

A process for making this new chemical product has been studied in pilot plant, may be undertaken on a large scale if markets develop. Process details are given, including alternate separation methods. Produced dimethyl sulfide can be 99.95% pure if desired.

INDUSTRY'S ROLE IN UNIVERSITY PROGRAMS ON NUCLEAR ENGINEERING, J. F. Kaufmann, AEC, Washington, D. C., presiding.

Introduction: Activities of the AEC in University Programs on Nuclear Engineering, J. F. Kaufmann, AEC, Washington, D. C.

Industry's Role in University Programs on Nuclear Engineering, D. W. McLenegan, General Electric Co., Richland, Wash.

Any large nuclear education undertakings will require that industry forecast needs on a long-range basis and portray to the universities the nature and extent of fundamental vs. specialized emphasis in nuclear education.

Industrial Participation in University Nuclear Engineering Program, R. Mainhardt and R. P. Geckler, Aerojet-Nucleonics, San Ramon, Cal.

One of the ways Aerojet works with the University of California is the offering of a reactor training course based on its AGN 201 training reactor in which student participation is encouraged.

Operation Bootstrap, S. F. Malaker and A. C. Stanton, Daystrom Nuclear Division, West Caldwell, N. J.

A discussion of the varied peaceful applications of nuclear energy in our society and the problems facing industry, such as organization, training, and staffing.

The Subcritical Assembly in Engineering Teaching, W. F. Fagan, University of Florida, Gainesville, Fla.

The light-water-moderated subcritical assembly of natural uranium has considerable potential as an aid to effective engineering teaching in nuclear technology.

TUESDAY, JUNE 11

GENERAL PAPERS II, Brymer Williams, Univ. of Mich., Ann Arbor, Mich., presiding.

Kinetic Studies of Carbonation Reactions Using a Radioactive Tracer, D. M. Himmelblau and A. L. Babb, Univ. of Wash., Seattle, Wash.

The application of radioactive tracer techniques to the determination of kinetic reaction rate constants in heterogeneous systems. The technique used, with its variations, is expected to have numerous applications.

Reaction Kinetic Studies—Catalytic Dehydrogenation of Sec-Butyl Alcohol to Methyl Ethyl Ketone, J. J. Perona and George Thodos, Northwestern Tech. Inst., Evanston, Ill.

The reaction kinetics for the catalytic dehydrogenation of sec-butyl alcohol to methyl ethyl ketone have been investigated at atmospheric pressure and temperatures ranging from 650° F. to 750° F. in the presence of solid brass spheres ⅛ inch in diameter. The nature of this catalyst permitted a direct evaluation of the surface involved in this reaction and allowed the definition of a surface-feed ratio to be expressed as S/F in place of the conventional weight-feed ratio.

Froth Stratification and Liquid Mixing in a Bubble Tray Column, R. D. Crozier and Brymer Williams, Univ. of Mich., Ann Arbor, Mich.

The hydraulic characteristics of both bubble-cap and sieve trays in a 13 by 7.5 inch rectangular column. The effect of operating variables on the local density distribution in the froth and the degree of liquid mixing.

Plate Efficiencies for Absorption and Desorption in a Bubble-Cap Column, L. A. Warzel and Brymer Williams, Univ. of Mich., Ann Arbor, Mich.

The effects of operating variables on plate efficiency for a small column when liquid phase reactions have no effect on the rate of transfer and the major resistance to mass transfer exists in either the gas phase or the liquid phase.

Equilibrium in the System Cu—Na—Dowex 50, H. C. Subba Rao and M. M. David, Univ. of Washington, Seattle, Wash.

Equilibrium correlations for the cation exchange of copper and sodium on Dowex 50 resin in solutions from 0.1 N to 4 N in chloride content.

FILTRATION (Simultaneous with General Paper Session II) F. M. Tiller, Univ. of Houston, Houston, Tex., presiding.

Method for Correlating Rotary Vacuum Filter Cake Moistures, P. A. Nelson and D. A. Dahl.

(Continued on page 82)

Can Atlas solve your
CORROSION PROBLEM?
. . . WITH ENGINEERING DESIGN?
. . . WITH TECHNICAL ADVICE?
. . . WITH HIGHEST QUALITY MATERIALS?
. . . WITH COMPLETE CONSTRUCTION FACILITIES?
. . . OR ALL FOUR?

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The answer is YES! Atlas is prepared to furnish the best and most economical solution to your plant-wide corrosion problems. Atlas can do the job.

For complete facts write for Bulletin CC-3.

SEATTLE PROGRAM

(Continued from page 81)

strom, Northwestern Tech. Inst., Evanston, Ill.

A method for incompressible cakes derived by theoretical means and applied to data on filtration of corn gluten and taconite iron o e concentrate. Results presented graphically permitting easy determination of the most economical filtration area and operating conditions.

Prediction of Resistance in Constant Pressure Cake Filtration, D. R. Boylan and F. H. Kottwitz, Iowa State College, Ames, Iowa.

Mathematical correlations between predicted and actual specific resistance values, based on commercial scale equipment tests.

Laboratory Scale Precoat Filter Test Leaf, P. W. Leppla, E. L. Neu, H. T. Kobata, Great Lakes Carbon Corp., Walteria, Cal.

Until the development of the test leaf with controllable shave-off described in this paper, no laboratory scale test device was available for the study of process variables in precoat filtration. With the new device a complete study of major process variables can be completed in a few hours with a relatively small volume of slurry.

An Analysis of Rotary Precoat Filter Operation, G. R. Bell and F. B. Hutto, Jr., Johns-Manville Corp., Manville, N. J.

A new concept in the interpretation of rotary precoat filter operating data has been developed. From observations made it is possible to predict changes in operating conditions which result in improved filtration efficiency.

The Role of Porosity in Filtration IV—Theory of Rotary Filtration, F. M. Tiller and H. R. Cooper, Univ. of Houston, Houston, Tex.

Analyses of equations presently used for rotary vacuum filtration revealed theoretical imperfections in several basic assumptions. New sets of equations have been derived for several different conditions including: 1) variable hydrostatic head; 2) Changing average specific resistance characteristic of constant pressure filtrations completed in a short period of time; 3) changing moisture content with accompanying compaction of cake.

FILTRATION II, F. M. Tiller, Univ. of Houston, Houston, Tex., presiding.

Non-Woven Filter Media, A. C. Wrotnowski, American Felt Co., Glenville, Conn.

Filtration characteristics and economic advantages are compared for non-woven filter media including mechanically interlocked fibers, wool felt, and bonded fabrics.

Predetermination of Particle Size Retention—Papers, Felts, Non-Woven Fabrics, J. F. Zievers, R. L. Crain, and W. L. Werchun, Industrial Filter & Pump Manufacturing Co., Chicago, Ill.

Present methods of determining particle retention where precoats are not employed require equipment not commonly available. Here is an accurate simple method.

WEDNESDAY, JUNE 12

GENERAL PAPERS III, C. A. Rohrmann, General Electric Co., Richland, Wash., presiding.

Design of Plutonium Processing Plants, B. F. Judson, General Electric Co., Richland, Wash.

Experience in design of a hazardous processing plant gained in the operation of a semi-works facility at Hanford Atomic Prod-

(Continued on page 86)

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A report from the White Sulphur Meeting

REGISTRATION— professional or legal?

Compulsory State registration of all professional engineers seems inevitable. What role should the engineering societies assume in these regulations and enforcement procedures? What restrictions, if any, should be placed on the practice of engineering by corporations and by private consultants?

The complex questions of law, public interest, and professional status involved in State registration of professional engineers were put under the microscope by a representative panel * at the recent White Sulphur Springs Management Conference of the A.I.Ch.E. (White Sulphur Springs—March 3).

Registration of engineers stems from the constitutional right of the States to "register the practice of the professions in the interest of public welfare and safety." So cited registration official Hodges, who thus posed a question which, sooner or later, must be decided State by State: who will establish the qualifications for professional certification—the politicians or the engineering societies?

In Michigan, said Carron and Katz, qualified members of the profession do make up the tests under the present set-up. "But," asked forward-looking Kuist, "will the engineering profession itself accept certification of its members as tantamount to professional recognition?" "It's being done already," reported pro-registration Neill of Dow, who went on to describe the system employed at the Freeport (Texas) Engineering Division of Dow.

"In our department," said Neill, "we have made a practice for several years of encouraging professional registration among members of our engineering staff. We have found that this policy pays off in more than one way. Not only does it foster a new sense of professional pride and individual responsibility, but we have noted also a distinct improvement in the technical quality of the work produced, as well as a greatly reduced turn-over in our staff.

"Whenever possible," continued Neill, "we try to reward registered engineers by promotion and increased responsibility. In fact, at some levels, only registered men are considered at all. All of our drawings now carry the professional seal of the individual engineer who did the design work; checking of drawings has been virtually eliminated."

A slightly different slant was taken by Moderator Carron: "It is by no means axiomatic that registration is necessary for an engineer to be recognized as a professional man. Registration does not guarantee competent technical performance or ethical conduct on the part of an individual engineer. It does mean, however, that he has been examined by eminent members of his profession and found to have a certain minimum knowledge of the technical aspects of his profession and of its traditional ethical standards."

The panel was almost unanimous in the opinion that, regardless of the merits of the case, the tide today in the United States is setting strongly in the direction of universal compulsory registration. In the words of Katz, University of Michigan, "In the long run, engineers are going to have to accept registration. However, it cannot be too strongly emphasized that this constitutes only one of the ways in which engineers can obtain public recognition of their professional status."

Hodge, of the West Virginia State Board of Registration for Professional Engineers, pointed out salient features of the current trend toward unification in registration practices: "There is a general trend toward higher requirements on the part of the States and an increasing effort to enforce the existing laws in this connection. In addition, the National Council of State Board Examiners is making an intensive drive to obtain uniformity of requirements to make possible reciprocity between States."

Long Range Policy

Kuist, of Fluor, advocated an all-out effort on the part of the engineering societies to maintain and expand their role in promoting the interests of their members, suggesting that "all engineering societies should set up their own standards and should police their own ranks to see that these standards are strictly upheld. Eventually, it is to be hoped that this method of self-discipline will prove so effective that State registration will be universally recognized as no longer necessary."

Commenting on this statement, Carron pointed out that in many States registration requirements are much stricter than those of the professional societies. "In fact," he said, "in the Northeastern States, where requirements are, in practice, generally set by qualified engineers rather than by politicians, experience has shown that about 50 per cent of academically-qualified applicants fail to pass the State registration examinations. This situation would have to be corrected before we could expect to be trusted with the whole task of registration and supervision."

Political Hot Potato

As to corporation practice of engineering, there is a little-enforced New York State law which, if enforced or revised (as is now being advocated by an EJC Committee in a resolution * objected to by the A.I.Ch.E. Council), would force many firms which entered the field after about 1935 to close. "A deplorable situation," said Kuist, whose words were echoed by Katz in somewhat different terms: "I would hate to see our nation deprived of the engineering contributions of teams working as practising corporations, particularly for the larger projects. The concept of individual responsibility is entirely outmoded and unrealistic in these days when no man can know enough about every angle of a vast project to be able to certify that the design and construction has been carried out by the best methods and is in the public interest."

* T. J. Carron, Ethyl Corp., Detroit, Mich. (Moderator); W. W. Hodge, W. Va. State Board of Registration for Professional Engineers; B. B. Kuist, Fluor Corp., Los Angeles, Calif.; E. T. Neill, Dow Chemical Co., Freeport, Texas; D. L. Katz, University of Michigan.

* The EJC resolution proposed that a corporation be permitted to practice engineering only if a majority of its officers are registered engineers and if all engineers in "responsible charge" are also registered.

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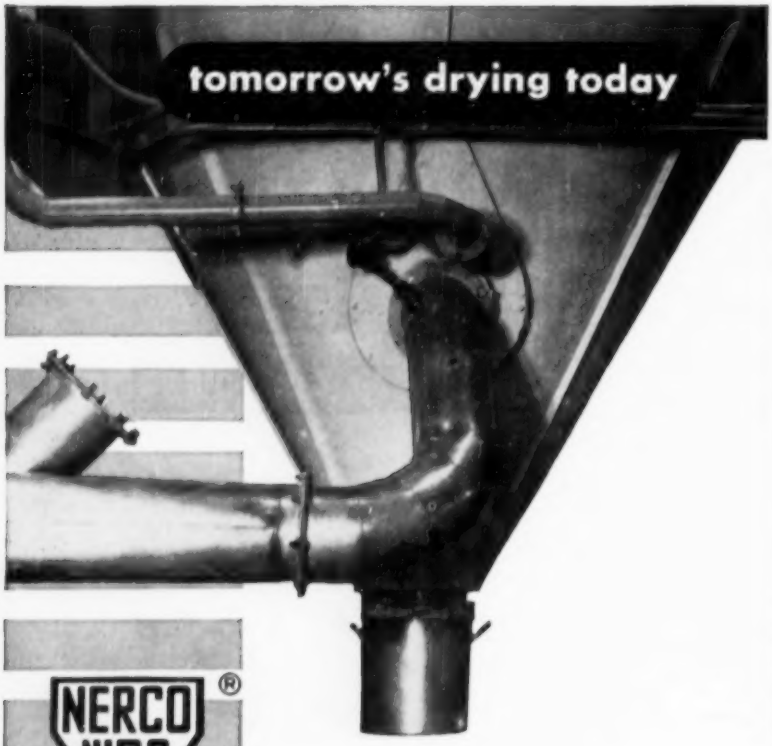

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SEATTLE PROGRAM

(Continued from page 82)

ucts Operation, including such prime design concepts as partial separation of operating and maintenance functions in the physical layout, and inclusion of multicomponent processing systems.

Development of Agitated Trough Continuous Calciner, M. J. Szulinski, General Electric Co., Richland, Wash.

Engineering development of equipment for the continuous calcination of UNH to UO_3 through three stages of scale-up, with the engineering data and heat transfer coefficients involved.

Radioactivity Levels and Temperature Variations of the Columbia River, R. E. Rostenbach, General Electric Co., Richland, Wash.

Radioactive cooling waters from the Hanford atomic reactors are safely discharged into the Columbia River. Problems and methods of handling are analyzed.

Application of the Packed Column to the Redox Process, E. R. Irish, General Electric Co., Richland, Wash.

The Redox solvent extraction process—main attention is given to performance characteristics determined for packed solvent extraction columns during development work, their interrelation, and instrumentation.

Production of Heavy Water, W. P. Bebbington, DuPont Savannah River Laboratory, Aiken, S. C., and V. R. Thayer, DuPont, Wilmington, Del.

Just declassified, this is a detailed description and analysis, including cost factors, price, technological processes, of the two heavy water plants operated for AEC by DuPont.

CHEMICAL ENGINEERING DATA AND CALCULATION METHODS I (simultaneous with General Papers III), W. C. Edmister, Cal. Research Corp., Richmond, Cal., presiding.

Thermodynamic Properties of Polar Compounds, Part I—Heats of Vaporization, A. Bondi, Shell Development Co., Emeryville, Cal.

A new method for the calculation of the heat of vaporization of hydroxylated compounds to an accuracy of about ±0.5 kcal/mole from no more data than the molecular structure and a boiling point.

Part II—Surface Tension and Critical Temperature, A. Bondi, Shell Development Co., Emeryville, Cal.

A method for extrapolating the surface tension of polar substances from a single surface tension datum point over a wide temperature range, provided the critical temperature and heat of vaporization of the substance are known.

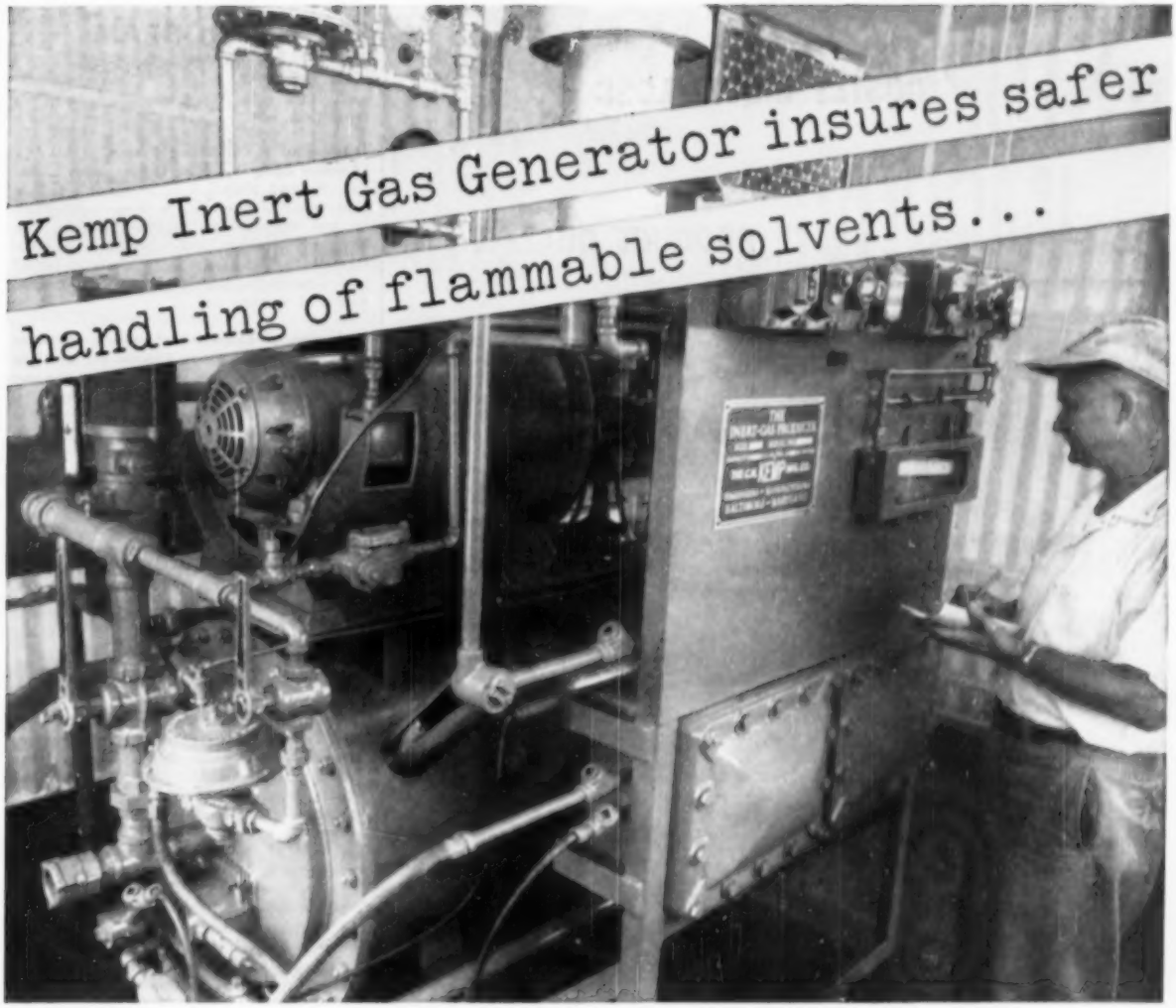
Equilibrium Ratios of Hydrogen and the Critical Loci of Hydrogen Paraffin Mixtures, J. M. Lenoir and H. G. Hipkin, C. F. Braun & Co., Alhambra, Cal.

A correlation to predict equilibrium ratios and critical loci for mixtures of hydrogen and paraffin hydrocarbons.

Vapor-Liquid Equilibrium Data for the Ternary System Cyclohexane-Heptane-Toluene, H. S. Meyers, C. F. Braun & Co., Alhambra, Cal.

Previous papers have reported equilibrium data for the binary systems cyclohexane-heptane, heptane-toluene, and cyclohexane-toluene. This study gives similar data for the ternary system, and compares the activity

(Continued on page 88)



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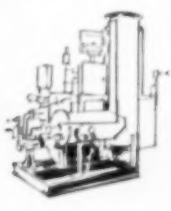

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SEATTLE PROGRAM

(Continued from page 86)

coefficients with those predicted from the three limiting binaries.

The Use of a Computing System at a Large Chemical Company, F. A. Landee, Dow Chemical, Midland, Mich.

Methods of operating a computing system so that the average engineer, with a few hours of instruction, can work his own problems on the machine. The nature and use of such a computing system is described, selected problems worked out.

Evaluation of Benedict-Webb-Rubin Equations for Prediction of Phase Equilibrium of Light Hydrocarbon Mixtures at Low Temperatures, A. R. Price, T. W. Leland and Riki Kobayashi, The Rice Institute, Houston, Tex.

This study is based on original data for the methane-ethane-propane system at temperatures down to —200° F. and pressures up to the critical, points to the weakness of the equation in the prediction of K-values for ethane and propane and perhaps for high molecular weight hydrocarbons.

CHEMICAL ENGINEERING DATA AND CALCULATION METHODS II, R. W. Moulton, Univ. of Wash., Seattle, Wash.

Machine Computation of K Values, E. Gordon, M. J. Goodwill, and J. W. Paylor, United Gas Corp., Shreveport, La.

One of the most accurate graphical K-value correlations available has been converted into the form of relatively compact equations suitable for use with digital computers, thus making it possible to eliminate this obstacle to an integrated machine computation system.

Solution of a Multicomponent Distillation Problem with Two Feeds or with a Sidestream, R. J. Hengstebeck, Standard Oil Co. (Indiana), Whiting, Ind.

Multicomponent distillation problems involving two feed streams or a sidestream can be solved by a graphical method developed for simpler towers. Certain special treatments are required.

New "Relative Volatility" Gives More Accurate Minimum Trays, F. W. Winn, Fractionation Research, Inc., Alhambra, Cal.

A new relation between the vapor-liquid equilibrium ratios of two components has been developed. The relation holds accurately for many systems at constant pressure even though the temperature may vary several hundred degrees. An application is illustrated.

Development and Application of General Purpose Analog Computer Circuit to Steady State Multicomponent Distillation Calculations, N. G. O'Brien and R. G. E. Franks, DuPont, Wilmington, Del.

The use of a general purpose analog computer for plate-to-plate computation of steady state non-ideal multicomponent distillation and absorption. It was found that the analog computer can be programmed much more rapidly for this type of problem than a digital computer.

Optimum Design of Ejectors Using Digital Computers, L. A. DeFrate and A. E. Hoerl, DuPont, Wilmington, Del.

Extension of one-dimensional analysis of single-stage jet ejectors by accounting for the effects of dissimilarities in molecular weights between the motive and suction gases. Numerical solution of the resulting non-linear simultaneous equations is done on digital computers.

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Lummus Turns Roundhouse into Beryllium Metal Plant for The Beryllium Corporation

$4,000,000 project to be completed by August 1957

On September 6, 1956 Lummus began initial process engineering and design of a $4,000,000 plant to extract beryllium metal from beryl ore. Scheduled to start operation on August 6, the new plant over the next five years will produce 500,000 pounds of the light metal — all contracted for by the A.E.C. Beryllium is used extensively in atomic reactors where it is an excellent moderator and neutron reflector, because of the small mass of its nucleus and its low affinity for slow neutrons.

Last year The Beryllium Corporation acquired a 2000-acre tract of land at Ashmore, Pa., including some old railroad buildings. The company called on Lummus, to design and construct the beryllium metal plant in the locomotive roundhouse.

The Lummus design accomplishes the extraction of beryllium metal from its ore — while giving prime consideration to the health and safety of plant operators.

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Old locomotive roundhouse at Ashmore, Pa., will soon be producing beryllium metal for use by the Atomic Energy Commission

Chemical Progress Week — April 8-12

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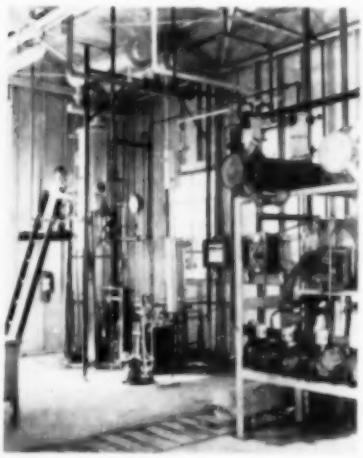
RESEARCH NEWS

A new type of contract research organization has been established in Great Britain to undertake fundamental scientific investigations for clients. Named the Arthur D. Little Research Institute, the new facility is located at Inveresk near Edinburgh, is sponsored by Arthur D. Little, Inc. and several prominent individuals in the United Kingdom. While costs will be borne initially by American funds, future research projects will be open to British and continental sponsorship on comparable terms. The majority of the staff will be British, but it is planned that scientists from the continent will be added. □

A new research unit responsible for an accelerated program of evaluating new chemicals as vinyl stabilizer components has been formed by Nopco. □

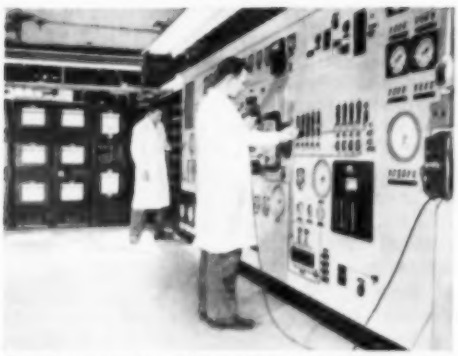
An advanced semi-conductor laboratory has been established by General Electric to bridge the gap between basic research and semi-conductor project engineering. The new lab will be located at Electronics Park in Syracuse, N. Y. □

To double its research facilities at Pittsburgh, Pa., Neville Chemical Co. is spending $750,000. Work will be done on resins and other coal and petroleum by-products and the expansion will include a new building, new equipment, and a 50% increase in staff. □



A marine testing laboratory to study marine distilling plants has been set up by Griscom-Russell Co. at the Harbor Island, N. C., station of International Nickel Co. Purpose of the lab is to aid Griscom-Russell in its search for more efficient and economical distillation equipment under a recently awarded research and development contract with the Dept. of the Interior, Office of Saline Water Research, in the application of low-thermal-difference distillation.

Taking the measure of tomorrow...



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COMPUTERS AND ENGINEERING DESIGN

- How useful can large digital computers be in engineering design work? What are their limitations?
- How does a company get a start in this type of work and what is the best way to build up an efficient working group?
- Can computers pay for themselves in hard cash?
- What size, kind of machine should an engineering company buy or rent?

CEP has attempted to get answers to these and related questions through conferences with two large engineering design firms which have ventured into the computer field and which are using computer methods to some extent in their day-to-day design work. The two companies are M. W. Kellogg of New York and Blaw-Knox of Pittsburgh. One has chosen the route of purchase of a medium-sized machine. The other rents time on large installations. Which is best? Here are the various considerations.

The experience of M. W. Kellogg in the use of digital computers dates back several years. Contrary to the usual sequence of events, the use of computers at Kellogg was initiated in the engineering organization rather than in the accounting department.

First significant work in this direction was done with the aid of a CPC (IBM Card Programmed Calculator). Results were so encouraging that it was decided to investigate the acquisition of a large digital computer. A study was made of the various types of process and design calculations which could be expected to be amenable to machine methods.

In May, 1956, Kellogg acquired a Datatron, a medium size digital computer manufactured by the Electro-Data Division of the Burroughs Co. The machine was taken on a rental basis which included maintenance by the manufacturer. Kellogg considers that it is better policy to rent such a machine rather than to buy outright, since improvements come along so fast that any given machine is apt to be obsolete within a few years of the purchase date.

When Blaw-Knox entered the computer field about three years ago, their purpose was two-fold: first, to develop *generalized* machine programs to relieve top-flight design engineers from routine stress analysis work; second, to build up a service bureau to sell computing services to outside engineering firms.

When the decision was taken to contract for the use of a computer, Blaw-Knox chose one of the largest then available—Remington Rand's Univac. Speed of calculation was considered critical in the economics of computer operation.

A large part of Blaw-Knox's computer work is at present carried out at the Remington Rand Service Bureau in New York. Since charges for this type of rental service are on an hourly basis, every minute counts and great care must be taken in the preparation of work for the machine. Hyman Kalson, who heads Blaw-Knox' computer group, says that much progress has been made in the technique of shifting from one problem to the next. Change-over is now almost instantaneous, and it has become economical to run groups of several short problems—one after the other.

What Work?

At Kellogg, an executive policy decision was made at the start that the medium-sized machine would be used only for long, complicated problems; short problems were to be avoided even if they were repetitive.

First practical work on the Datatron consisted of mass spectrograph calculations for the research laboratory. Then a program was set up which entails machine solution of a large number of what might be called "prefabricated" design problems, in which most likely combinations of variables are used. As this work progresses, active recourse to these by the design engineers is expected to save greatly in time, cutting down on routine detail. Present types of problems being "presolved" include:

1. Fractionating tower calculations on a tray-to-tray basis. Superiority of the machine here is that no simplifying assumptions need be made. A close approach to optimum design is said to be thus assured.
2. Solution of the stress and flexibility problems involved in complicated piping systems.
3. Design of heat exchange equipment of all types, including condensers, reboilers, etc.
4. Design of various types of furnaces for chemical and petrochemical process applications.
5. Overall heat and material balances. This is being done for a variety of process flowsheets. In particular, Kellogg is using their machine to throw generalized material balances around gasoline recovery systems, including strippers, absorbers, etc. A flow sheet for a more or less standardized ammonia synthesis process is also partially completed. Standardized flow sheets and material balances developed in this way are expected to serve two purposes: first, by very slight changes in the machine set-up, it will be possible to test out variations from the standard flow sheet without running through all the calculations again; and, secondly, it is hoped that they will prove to be a powerful tool for process evaluation from an economic standpoint.

Emphasis on Program Standardization

Up to the present time, Blaw-Knox has concentrated their computer operation principally in the analysis of the stress and flexibility problems involved in the design of highly complicated piping systems. This work has been carried on from the start in collaboration with Arthur D. Little, Inc., who are retained by Blaw-Knox on a consulting basis. ADL is supplying know-how in the setting up of problems for machine solution. Training of B-K personnel goes on as new types of problems are handled. In piping design work, Blaw-Knox says that their "6X6" Flexibility Matrix Method is an improvement over other existing methods for speed, simplicity, and accuracy. The data fed into the machine

(*Continued on page 94*)

Datatron installation in Kellogg's N. Y. offices. At machine, J. F. Skelly; at desk, A. M. Peiser.

Univac at work on a piping system design for Blaw-Knox. Left to right: R. McCollough, Remington Rand; P. Strong, A. D. Little; and H. Kalson, head of the computer group in Blaw-Knox' Power Piping Division.

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Planning the most effective approach to *your* drying problem is important to *you*.

There is first, the need of a well integrated research program such as we discussed in the first of this series of PROCTOR services last month.

Secondly, there is the need for a full understanding of the drying problem. Such understanding requires knowledge of a number of items; such as, the properties of the material to be processed, preliminary wet processing and preforming techniques and how they affect drying rates together with a familiarity with the advantages, as well as the limitations of all types of drying equipment. PROCTOR'S service provides the required understanding of your drying problem through the background of experience of PROCTOR Engineers.

Make use of this PROCTOR service! It will help you assemble all the essential data for the most logical solution to *your* drying problem.

Your material characteristics, capacity desired, initial and final moisture conditions, permissible operating temperatures, corrosive conditions, and many other similar items enter into the considerations which must be given *your* problem. The analysis of such information will lead to the ultimate production of a quality product through the use of quality equipment.

Through the cooperation of your PROCTOR Engineer, such an analysis permits this pertinent information to be successfully translated into the preliminary selection of a drying system.

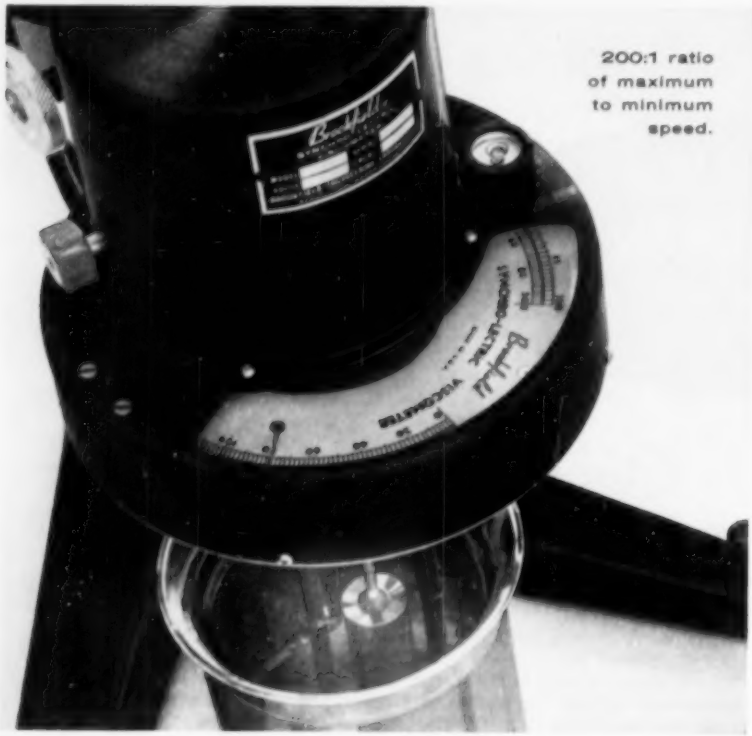
And there is more to PROCTOR'S service. Before this preliminary choice can be made final, the exact conditions under which the material will be processed must be established by a controlled test program. These tests provide the basis for accurately sizing the commercial installation; they are the foundation of PROCTOR'S guaranteed performance.

The importance of this test program, and details of this part of PROCTOR service will be more fully covered next month.

Why not call us at PROCTOR? We welcome the opportunity of serving you as we have so many others, in order to achieve the successful and economical solution of a drying problem.

Proctor

PROCTOR & SCHWARTZ, INC.
PHILADELPHIA 20, PA



200:1 ratio of maximum to minimum speed.

IF VISCOSITY IS ONE OF YOUR PRODUCT'S DIMENSIONS

Brookfield 8-speed Viscometer will answer every measurement problem!

Why not invest a three-cent stamp and see what we mean? Our illustrated brochure shows you how the Brookfield 8-speed viscometer and specialized accessories will answer every viscosity measurement problem you may have. You'll see how this one, easily operated, portable instrument will provide precise measurement readings directly in centipoises. Even in applications involving extremes in viscosity, temperature or corrosion!

Complete information will be yours, too, about the Brookfield Helipath Stand. With it, it's easy to test, study and control highly-plastic materials, gels and semi-gels. It automatically lowers a Brookfield Viscometer equipped with a special bar-type spindle through a helical path providing constant measurement of undisturbed material. Write for full information today.

WORLD'S STANDARD FOR VISCOSITY MEASUREMENT

Brookfield

ENGINEERING LABORATORIES INCORPORATED

STOUGHTON 18 , MASSACHUSETTS

COMPUTERS

(Continued from page 92)

consist only of dimensions that can be easily taken from an isometric drawing of the piping system and a few physical properties of the pipe material.

It can thus be seen that the input to the machine is basically no more complex for complicated systems than for simple ones; for large piping systems, the only difference is that there are more sets of values, which means somewhat more time to feed the information to the machine and proportionally more machine time for solution. According to Kalson of Blaw-Knox, the average piping problem requires about one hour of machine time and almost any problem can be completely carried through in one day, if necessary.

In calculating power piping systems by hand methods, the quality of the final work depends to a considerable extent on the ability of the engineer who performs the calculations. This constitutes a very real limitation which automatically disappears when the machine method is adopted.

In the view of Blaw-Knox, standardized programs of design problems are the only way for engineering organizations to use computers economically—the machines are too expensive to be employed in the solution of isolated problems except in exceptional circumstances.

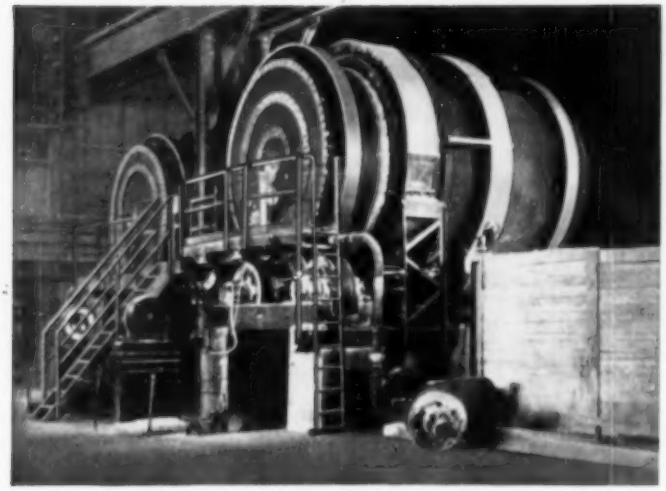
Only a Start

It is probable that Blaw-Knox's specialization in the area of piping design is only a jumping-off point for more extended computer applications within the company. They are at present making a careful and detailed study of the feasibility of using computers in other parts of their organization such as their Chemical Plants Division and their Fabricated Products Group. But, they have not yet decided whether to purchase a large digital machine, several smaller machines, or whether to continue their present policy of renting time on what they consider the most efficient machine for the job at hand. Says D. F. Jurgensen, vice president in charge of research, "We are sure that this new tool will play an increasingly important role in all of the company's design and fabrication activities."

Training Methods

When Kellogg acquired the Datatron, a small contingent of engineers from their New York offices was sent to Pasadena for a short period of preliminary training on the machine. Since that time, all training has been done in New York by Kellogg per-

(Continued on page 96)



Two Semi-Continuous Batch Rotary Kilns Pre-heating Electric Furnace Charges.

Two Oil-Fired Rotary Kilns in Midwestern Manufacturing Plant.

Rotary Waste Disposal Kiln Showing Skip Loader and Brick Ash Collection Chamber.

Batch AND Continuous Kilns

3 TYPES for a wide variety of pre-heating, processing and disposal operations

Bartlett-Snow batch kilns are ideally suited for pre-heating electric furnace charges. They bring the material up to temperature and remove moisture with a less expensive gas or liquid fuel, and shorten the furnace heating cycle, increasing its output.

Gas or oil-fired continuous kilns are designed for applying ceramic coatings to granules, calcining and nodulizing ores, and oxidizing and reducing operations at temperatures from 1000° F to 2200° F. Cylinder rotating speed can be varied to control the time the material is under treatment. Burners are controlled automatically with radiation pyrometers. Heated material can be cooled in separate equipment at gradually declining temperatures if desired.

Waste disposal kilns equipped with automatic equipment provide an efficient, smoke-free method of disposing of combustible liquids, sludges and other industrial waste materials.

Use our complete facilities, including materials handling, on your next job! It fixes unit responsibility; assures the smooth, synchronized operation of the entire project; and utmost economy and satisfaction!

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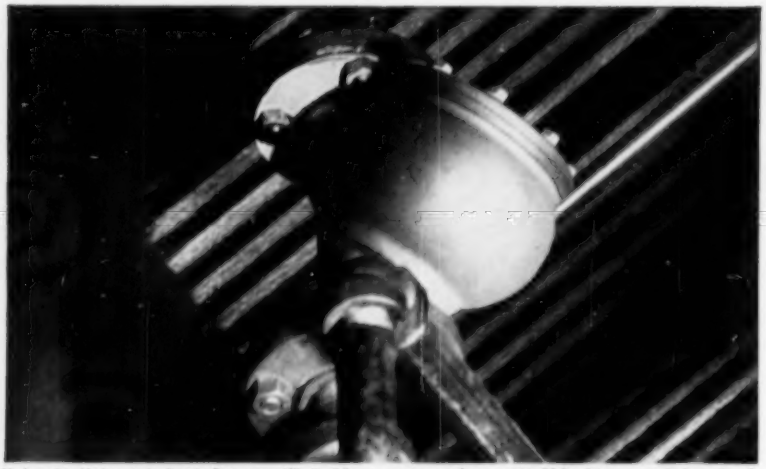
DRYERS • COOLERS • CALCINERS • KILNS — *Complete Facilities Including Materials Handling*



Underwriters' Laboratories lists the Protectoseal "in-line" flame arrester vent for use within 50 ft. of the open end of vent lines.*

THIS "IN-LINE" TANK VENT PUT AN END TO DANGEROUS ROOF-TOP MAINTENANCE!

The above illustration shows the "in-line" vent located inside the tank house some 20 ft. from the open end of the line. This avoids frequent, costly and highly dangerous roof-top inspection formerly necessary where vents were installed outside at the end of the vent lines.

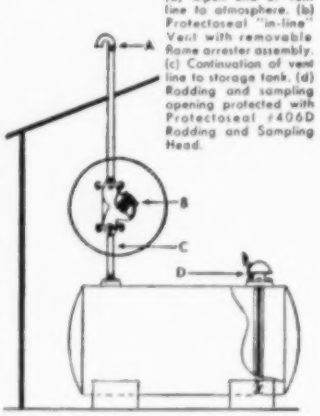
PROTECTOSEAL ENGINEERING SERVICES

The development of this "in-line" flame arrester vent is typical of Protectoseal design and engineering versatility. In providing proper fire and explosion protection, consideration is always given to the operating and maintenance problems of corrosion, sublimation, valve pressures, conservation of solvent vapors, cleaning of flame arresters and other special problems.

PROTECTOSEAL VENTING MANUAL

For a fuller understanding of how Protectoseal can help you solve your venting problems, fill out coupon below for your copy of the complete Venting Manual showing operating features and special applications of the complete Protectoseal line.

*The 1" in-line Flame Arrester Vent is approved for installations at distances up to 50 ft. from the open end of vent lines from flammable liquid storage and process tanks; 2" and larger sizes are approved for installation at distances up to 20 ft. from the open end of vent lines.



(a) Open end of vent line to atmosphere. (b) Protectoseal "in-line" Vent with removable flame arrester assembly. (c) Continuation of vent line to storage tank. (d) Rodding and sampling opening protected with Protectoseal #406D Rodding and Sampling Head.

Diagram shows actual installation of the Protectoseal "in-line" Flame Arrester Vent. Note how the vent is installed inside the tank house.

A COMPLETE LINE OF STORAGE TANK SAFETY EQUIPMENT

Conservation Type Vents

Non-Conservation Type Vents

Rodding and Sampling Heads

Tank Truck and Tank Car Loading Covers

Storage Tank Fill Fitting

Working to prevent fires in cooperation with Underwriters' Laboratories, Inc., Associated Factory Mutual Fire Insurance Companies, National Fire Protection Association, Factory Insurance Association, Improved Risk Mutuals.

PROTECTOSEAL PRODUCTS
PROTECT YOUR PLANT

The Protectoseal Company, Technical Service Department,
1952 South Western Avenue, Chicago 8, Illinois

Please send the Venting Manual with Price List and the Safety Bulletin Series as checked below.

☐ Protectoseal Venting Manual

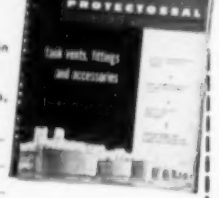
☐ Safety Bulletin Series on "Flammable Liquids, their characteristics, hazards and safe handling"

Name _____ Title _____

Company _____

Address _____

City _____ Zone _____ State _____



COMPUTERS

(Continued from page 94)

sonnel. The group working full time on computer operation is still small—about ten people in all, including programmers. While the group is technically part of the engineering department, their services are always available to any other department within the company. In fact, a conscious effort is made at Kellogg to acquaint all members of the company with the potentialities of the machine and with the scope of the work which can be performed by the computer group.

Mathematicians a Must

Based on Kellogg's experience, it is said to be almost essential that an integrated computer group include trained mathematicians as well as process engineers. The manager of the Mathematics Section of Kellogg's Development Division, A. M. Peiser, himself a mathematician by profession rather than an engineer, puts it this way:

"While engineers are necessary to contribute an understanding of the concepts involved in any particular process and the results which are to be achieved, we cannot, in all fairness, expect that the average engineer will be sufficiently versed in the advanced types of mathematics used today in computer calculations."

Blaw-Knox is now in the process of training a computer group within the company. Two young engineers of the Power Piping Division are now studying part-time at the University of Pittsburgh and it is planned that they will later be sent to a Remington Rand or IBM school for intensive work in computer operation and programming. (According to Kalson of Blaw-Knox, it is practically impossible for anyone to become a really expert programmer without formal training.)

There are now three men in the Blaw-Knox computer group. Two more are being trained and, by the end of the year, they expect to have five men on a full-time basis.

Machine Experience

Kellogg has found that repair and maintenance considerations are critical in the operation of a large-scale digital computer. In choosing a computer, they would advise that the closest attention be paid to the two factors:

1. What is the maintenance record of the computer in question?

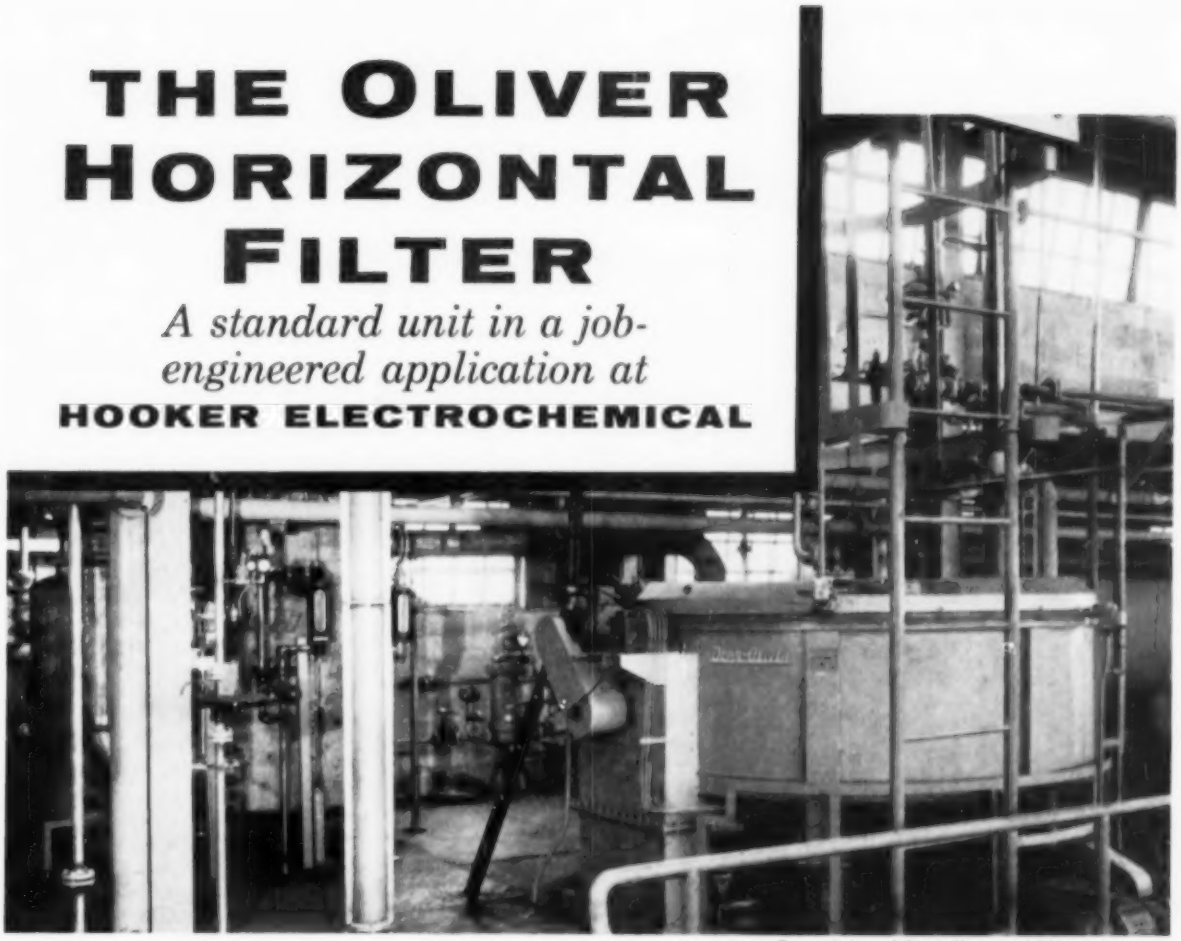
2. What additional services are included by the manufacturer in the sale of the computer,

(Continued on page 98)

THE OLIVER HORIZONTAL FILTER

A standard unit in a job-engineered application at

HOOKER ELECTROCHEMICAL



General view of Oliver Horizontal Filter station.

One of the most unusual and successful applications of the Oliver Horizontal Filter is at the Niagara Falls, N. Y. plant of Hooker Electrochemical Company.

This installation is unusual due to the highly specialized nature of the Hooker Process. The unit handles the dewatering, multi-component solution washing and final dewatering steps prior to thermal drying of HET Acid,* an ingredient of Hooker's flame resistant polyester resin, Hetron*. Basically constructed of stainless steel all direct contact components are coated with a non-contaminable, corrosion-resistant plastic. Product conditions require that the filter hood be of a liquid seal-vapor-tight design providing a completely closed air return system. Control is automatic and viewing ports with illumination are provided for full visibility through the entire cycle.

The ability of the unit to provide sharp filtrate separations ideally suits the Oliver Horizontal Filter for solution washes when several filtrates must be kept separate. This feature along with many other facets of the versatility inherent in the Oliver Horizontal Filter, such as high capacity per unit area and multi-stage counter current wash, qualifies the standard unit for such highly specialized applications.

The Hooker Electrochemical installation is an excellent example of Dorr-Oliver ability to provide the equipment to fit the job. For further information on the Oliver Horizontal Filter, write to Dorr-Oliver Incorporated, Stamford, Conn. Ask for Bulletin No. 7201.

*T.M. Hooker Electrochemical Company

Access port showing accessibility of interior components, inner scroll support bearing not in place, note vapor-tight construction.

Underside of filter showing accessibility of integrally mounted valve and filtrate piping.

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speed processing, cut costs

Slab, sheet, pelletized and coarse granular materials can be continuously washed, dried, heated or cooled while moving on woven wire conveyor belts. Operations proceed rapidly and uniformly under perfect control without manual handling. Packaging, weighing and sealing, too, become continuous production-line steps as moving belt carries packages past these stations. EXAMPLE:

Continuous Washing

MOVING BELT carries granular material continuously through hot water spray rinse.

OPEN MESH permits rapid drainage of rinse water and free circulation of cooling and drying air, yet the belt can be woven densely enough to retain small particles.

ALL-METAL BELT of corrosion resistant alloy is impervious to damage from heat or process solutions, even many acids and alkalis. Woven wire construction eliminates seams, lacers and fasteners that ordinarily wear and break.

SPECIAL RAISED EDGES hold material on belt, are typical of variety of side and surface attachments available to hold even the smallest size product during flat or inclined travel.

Cambridge Woven Wire Conveyor Belts are made in any size, mesh or weave, from any metal or alloy, and can be used under a wide range of conditions . . . from 2100° F. to sub-zero, wet or dry. Call your Cambridge Field Engineer to discuss how you can speed production and cut costs with continuous processing on woven wire conveyor belt. Look for his 'phone number under "Belting, Mechanical" in the Yellow Pages or write for FREE 130 PAGE REFERENCE MANUAL.

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WIRE CLOTH | METAL CONVEYOR BELTS | SPECIAL METAL FABRICATIONS

OFFICES IN PRINCIPAL INDUSTRIAL CITIES

COMPUTERS

(Continued from page 96)

such as mathematical help in setting up programs and in programming?

Programming Bottleneck

Kellogg has found further that the main bottleneck in computer work for design purposes is likely to be in the programming phase. The preparation of technical data for the machine is a long and tiresome job which, for the immediate future at least, seems to be unavoidable. In addition, most computers use different systems for programming and it is extremely difficult to change from one computer to another—even to a larger machine of the same manufacturer.

To overcome these drawbacks, new systems are being devised to standardize and to simplify programming techniques. Unfortunately, most of these systems seem to be less efficient in certain ways than the longer methods. The problem of changeover from one machine to another is presently being simplified by the introduction of built²in mechanisms which permit the computer to translate the program for itself.

Economic Evaluation

No amount of statistics on comparative man-hours, or on salaries vs. the cost of machine operation, can tell the whole story, emphasized Peiser of Kellogg. "If," he said, "by testing a multitude of possible process flow sheets and coming up with a solution involving maximum efficiency and minimum cost, the computer were to enable a design company to make a successful competitive bid on a large job, the profits might pay the rent for a year."

Employee Morale Problems

In recent years there has been a spate of more or less ill-informed talk about the coming industrial revolution, that is to say, the large-scale introduction of automation into industry. Such talk has made a considerable impression on the public imagination and has created a certain latent resistance to the introduction of computer installations.

Kellogg's approach to this problem emphasizes the point that, far from reducing their engineering staff, the machine is more likely to have the contrary effect—in the words of J. F. Skelly, manager of Kellogg's Development Division, "not to do the same work with fewer people, but to do more and better work with the same people."

Here's the Nation's NO. 1 Nitrogen Gas Generator

Only Gas Atmosphere's new Nitrogen Generator has all the features you have asked for in a production generator. It comes as a COMPLETE PACKAGED UNIT ready to be set on stream with a minimum of make ready. EXCLUSIVE AUTOMATIC TURN-DOWN enables production coincident with demand, eliminating gas waste. SIMPLIFIED RATIO CONTROL assures uniform gas analysis always. SINGLE BURNER OPERATION means easier combustion control. This new generator develops HIGHEST PURITY NITROGEN and, where required, CO_2 can be obtained from the same unit simultaneously. Here is truly the nation's top nitrogen generator. Be sure you look into it before you buy.

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A report from the White Sulphur Meeting

THE FUTURE FOR PLASTICS

Roger Williams, Jr., | Roger Williams Technical & Economic Services, Inc. Princeton, New Jersey

The plastics industry is a young industry, yet it turned out some four billion pounds of resins last year. It is growing at a rate that makes forecasting difficult, but certain trends are clear.

First, there is the trend to tailor-made resins for specific uses. In polyethylene there are already film grades, electrical grades, pipe grades, and so on. In phenolic resins there are some *2,000* different ones on the market. This business of concocting specific resins for specific uses is one of the major future paths in the industry—and it is one of the major reasons why the plastics industry is going to continue to have a healthy growth rate.

A second trend is that the chemical engineer is going to be called on not only to produce more uniform plastics continuously and cheaply, but to find ways of getting colors in his plastics less expensively. The engineer is dealing with materials of construction—better materials—and they will have to be more versatile.

Consumer whims—mostly of women—have determined who made the money and who lost it. While there is going to be a section of the plastics fabrication industry where specifications and performance will matter (hopefully, that will be a growing percentage of the total), most managements must expect a market that will be volatile from year to year. No company should base its economic calculations on operating at 100% of capacity.

Too Much, Too Soon?

Until recently the plastics industry was composed of the larger chemical companies which made and sold a fairly complete line of resins, and the small chemical companies which made specialties. (This does not include the paint companies, of course.) Today there is a different phenomenon—the entry of petroleum companies and non-plastic chemical companies with *big* capacities of a *single* resin. This has been particularly evident in the polyethylenes.

Now oil companies tend to think in terms of barrels rather than the pounds normal for chemical companies, and while 5 million pounds a year is a respectable output in the case of many chemicals, it represents only some 50 barrels a day if the chemical is all hydrocarbon. This output is practically nothing to any oil company. Since the quantities involved seem so small, there is a tendency to build bigger than a chemical company might do. The resultant over-capacity can reduce profits for all concerned. (Oil companies are not the only ones with this type of thinking. A steel company turned down a potentially profitable chemical venture because it would use so few tons of coal a day!)

The polyethylenes are going to be typical of this philosophy. Based on purchased ethylene, as many of the plants are, a ten million pound polyethylene plant would probably be economic. But the companies now involved in polyethylene expansion are coming in with 35-50 million pound capacities. If all those who have announced plants really build, there will be more capacity for the new low pressure, or linear, polyethylene by the end of next year than *all* the high pressure polyethylene the United States consumed in 1955—*ten years after* it was first introduced on the market. The break-even point for these new plants hopefully is very low.

Similarly, the chemical industry itself seems to have believed some of its own dreams of how fast a plastics market can be developed. As of a short time ago the two isocyanate producers were operating at 10% of capacity and since then a third producer has gone on stream.

The plastics industry is growing, and growing fast, but it cannot utilize at once quantities of new resins equal to the total markets for resins which have been around for years.

Hard to Predict

But growth in plastics has been so swift, and with such sweeping new developments, that a forecaster can hardly believe his own figures or predictions. As little as 30 years ago most chemists believed that ethylene could not be polymerized to a solid, high molecular weight polymer. It was thought that some other atom had to be present, such as the chlorine in vinyl chloride, or some other structure involved such as the benzene ring in styrene. This idea was disproved by an ICI research team some 25 years ago, and the discovery of ICI, plus the war, plus chemical engineers started polyethylene on its amazing growth.

Then the polymer chemists took over. Their work took time, but eventually the ethylene molecule was made to do all kinds of tricks. It is no longer just polyethylene—it is linear, branched, isotactic, high or low density, and so on.

Chemical Engineers

But where do the chemical engineers fit in? They design and build the polymerization plants, of course. But there is a much greater contribution the chemical engineer can make—and will make.

Take the older resins, the phenolics, alkyds, ureas and the like. They are still made mainly in batch equipment. If their volume is to grow they must be reduced in cost, and the same is true of modified versions of these polymers the chemist will develop in the future.

Obviously, if polymers are going to be reduced in cost, one of the prime methods is going to be improved chemical engineering. Engineers are going to have to learn more about removing the heat of polymerization evenly—to conduct polymerizations continuously on an adiabatic basis and with very close temperature control. Eventually engineers will have to stop talking about "average" molecular weight and a narrow molecular weight distribution, and learn how to make a polymer of a given single molecular weight—make it continuously, inexpensively, and make the same polymer day after day.

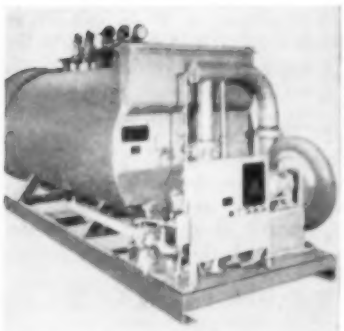
Integration or Not?

One question about the future of the industry is whether or not there will be more vertical integration. In vinyls there is a great degree of it already, and more is on the way. Within months there has been vertical integration in the purchase (or merger) of Visking by Carbide and Durethene by Koppers. But there is another side of the coin. DuPont has dropped out of the polyethylene film business even though such business is an obvious adjunct to the company's cellophane sales, and despite DuPont's position as a basic polymer producer.

Obviously, either DuPont is right and Carbide and Koppers are wrong, or *vice versa*. Sitting on the sidelines, and dealing mainly with markets

(*Continued on page* 102)

Deep cooked . . . and always uniform in color and flavor



A horizontal vaporizer (above) is used by the Wise Potato Chip Co. Low pressure performance (144 p.s.i. at 750° F.) of Dowtherm permits the use of compact, thin-walled equipment.

Wise Potato Chip Company solves uniform process heating problem with Dowtherm, Dow heat transfer medium

Faced with the unique problem of deep cooking uniform color, taste and crispness into their chips, a few years ago the Wise Potato Chip Company, Berwick, Pennsylvania, sought the answer to maintaining a constant temperature with varying heat loads.

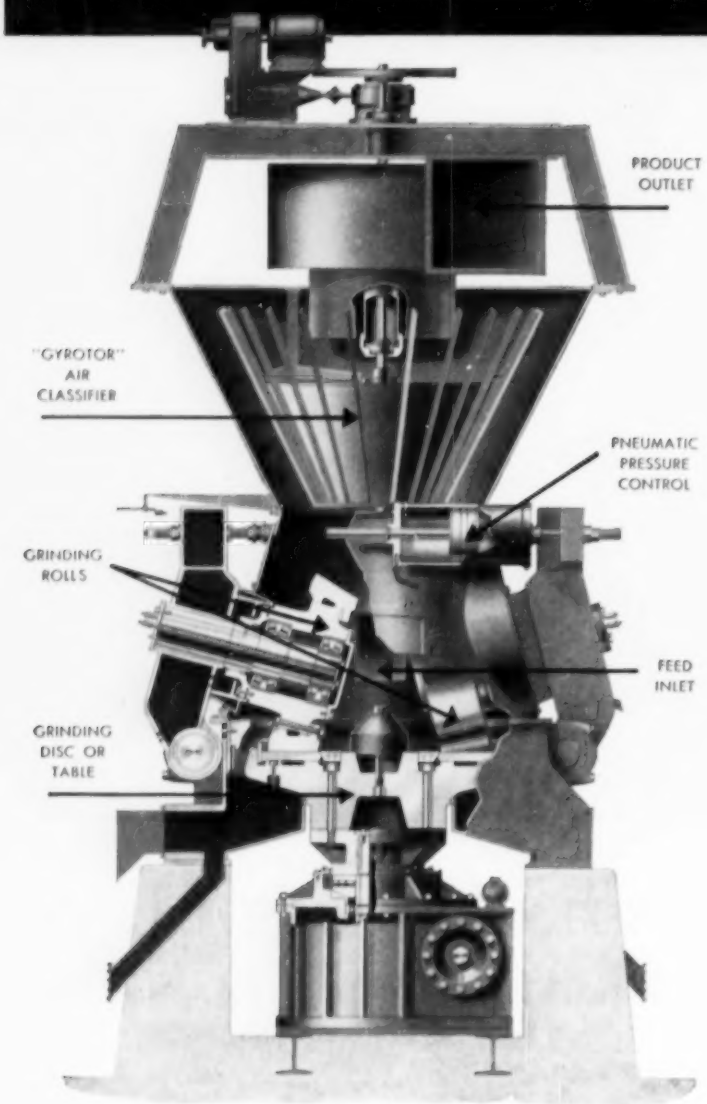
Intense examination of many heating systems led the Wise Potato Chip Company to select an entirely closed heating system using Dowtherm® as a vapor heating medium.

These results were soon apparent: Now heating efficiency is very greatly improved. Fuel costs are reduced. Fire hazards are reduced because with Dowtherm the heating source is placed far from the processing area. Quality is controlled more easily by the use of Dowtherm.

For your own peace of mind, if you have a process heating problem ranging from 350° to 750° F., we advise you to talk with us. We might have the answer that will improve your product—and save your company money. THE DOW CHEMICAL COMPANY, Midland, Michigan, Dept. BD 845J.

YOU CAN DEPEND ON DOW

DISC-ROLL MILL



The Hardinge Disc-Roll Mill is a roller-type mill with two adjustable, pneumatically loaded rolls for grinding material on a horizontal rotating disc or table (Loesche type). The Hardinge "Gyrotor" Air Classifier, in combination with the mill, provides a complete grinding, classifying, and drying system. A full description is given in Bulletin 52-40.

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RESEARCH NEWS

A new laboratory will be constructed by Catalin Corp. of America for the development of special chemicals. The lab will be located at the company's Fords, N. J., plant, will cost upwards of $500,000. □

To keep pace with growing nuclear engineering research activities, Babcock & Wilcox will expand its Alliance, Ohio, Research Center. □

For expanded research into the properties, applications, and improvement of high alumina ceramics, Diamonite Products Manufacturing Co., Canton, Ohio, has opened an extensive research laboratory at its manufacturing plant. □

A new laboratory for research on high polymers and for technical service on plastics materials has been opened by the Polymer Chemicals Division of W. R. Grace. □

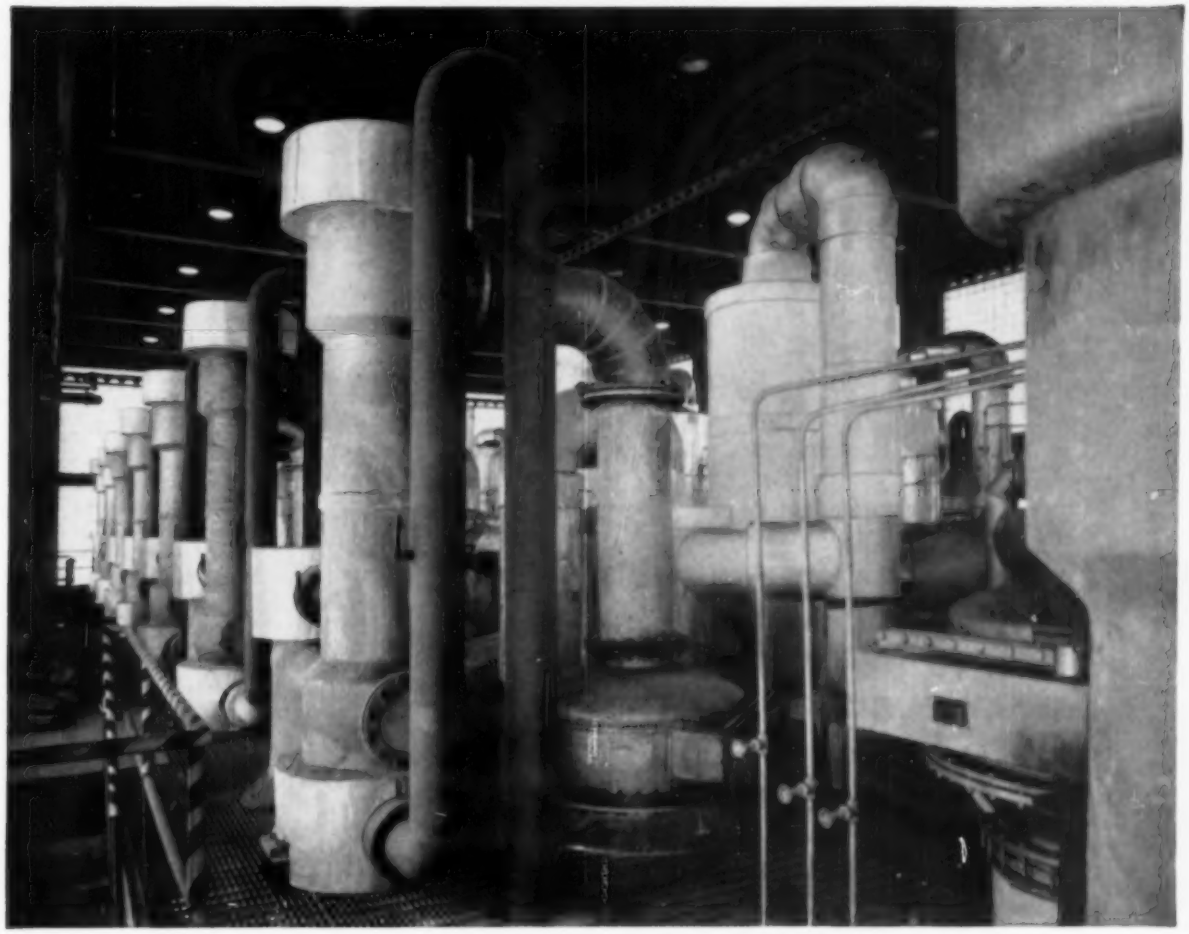
A new addition to American Potash & Chemical's Whittier, Cal., Research Laboratory cost $200,000, will double the work-space available in the laboratory, will enhance the company's expanded research program.

PLASTICS FUTURES

(Continued from page 100)

and marketing, it is difficult to say which decision will be the right one. My guess is that vertical integration will occur where there is a large investment required in the fabrication end—for example, in calandering vinyls. Where there is a small investment required in fabrication, the integration is more likely to be with distributors of competitive materials rather than backwards to the polymer producer.

The plastic industry has grown at a remarkable rate and in remarkable amounts when considered as an industry by itself. But when in perspective, on a cubic foot or cubic inch basis (because that is how plastics are used), the industry is dwarfed by wood, steel, glass, and rubber, and is just barely larger than the leather industry. On that basis, plastics still have a long way to go, but the future holds strong promise of their getting there.



EVERYWHERE YOU LOOK . . .

ALBERGER HEAT EXCHANGERS

Rarely does a heat exchanger manufacturer have the privilege of equipping a plant so completely as Alberger has had at the Tonawanda plant of BECCO Chemical Division, Food Machinery & Chemical Corp., a leading producer of hydrogen peroxide and related products. Floor upon floor, building after building of the modern BECCO plant is filled with Alberger Heat Exchangers — millions of dollars worth, every penny of it a testimonial to Alberger's dependability.

Yet, this big installation at BECCO is only one of 40,000 installations made by Alberger since its founding 53 years ago. In Alberger equipment, heating surfaces are scientifically arranged to increase heat transfer and compactly assembled to save floor space. And, all Alberger equipment is exceptionally accessible to save time and money in maintenance.

Photograph shows batteries of Alberger final condensers made entirely of aluminum for use in the production of hydrogen peroxide. Each final condenser has its own Alberger reflux condenser and its own Alberger "after" condenser. All final condensing units in both of Becco's plants — Tonawanda, New York, and Vancouver, Washington — made by Alberger.

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Mr. Gene Lane, Utility Operator, at the Central Soya Co., Inc., Chattanooga, Tenn. plant, operates 36 Merchen Scale Feeders that blend feed ingredients to 1% accuracy.

MERCHEN SCALE FEEDERS

"give us accurate, continuous blending over a wide feed range"

Central Soya Co., Inc., blends millions of bags of animal and poultry feed a year at their new Chattanooga plant. Up to 50 different formula feeds are produced to exacting standards. Central Soya chose W&T Merchen Feeders because they give 1% minute-to-minute accuracy over a wide feed range. As seen in the picture, the feeders are compact — with no bulky enclosures.

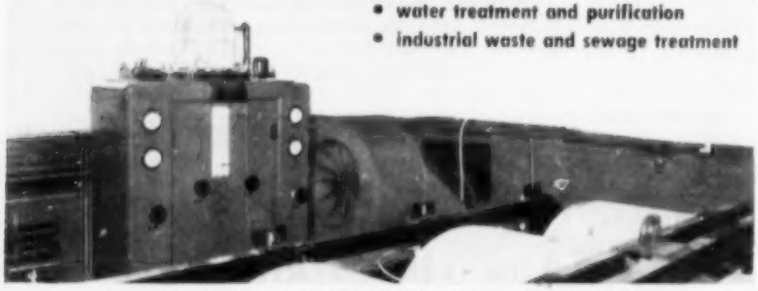
Merchen Scale Feeders, with feed rates from 3 to 3000 pounds per minute, require no adjustment for changes in material density. They are suited for most industrial continuous blending or automatic batching processes. For more information about Merchen Scale Feeders, write for Bulletin M-34.

WALLACE & TIERNAN INCORPORATED

25 MAIN STREET, BELLEVILLE 9, NEW JERSEY

CHLORINATORS and CHEMICAL FEEDERS

for
- slime elimination
- water treatment and purification
- industrial waste and sewage treatment



WALLACE & TIERNAN INCORPORATED

CD-41 25 MAIN STREET, BELLEVILLE 9, NEW JERSEY

OVERSEAS NEWS

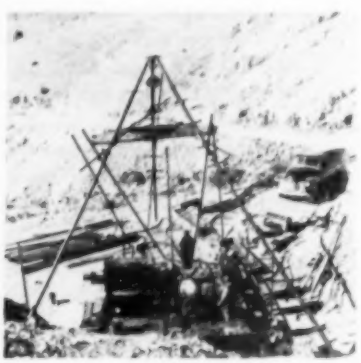
Production of sulfur has begun at Texas Gulf Sulphur's Mexican affiliate, Compania Exploradora del Istmo, S.A. The Mexican company only recently completed its Frasch System extraction plant at Nopalapa, state of Vera Cruz, on the Isthmus of Tehuantepec in southern Mexico. □

Cowles Chemical Co., Cleveland, has licensed Nightingale Supply Co. and its subsidiary Nightingale Silicates Pty. of Sydney, N.S.W., Australia, to produce Cowles' anhydrous sodium metasilicate and other detergent silicates. □

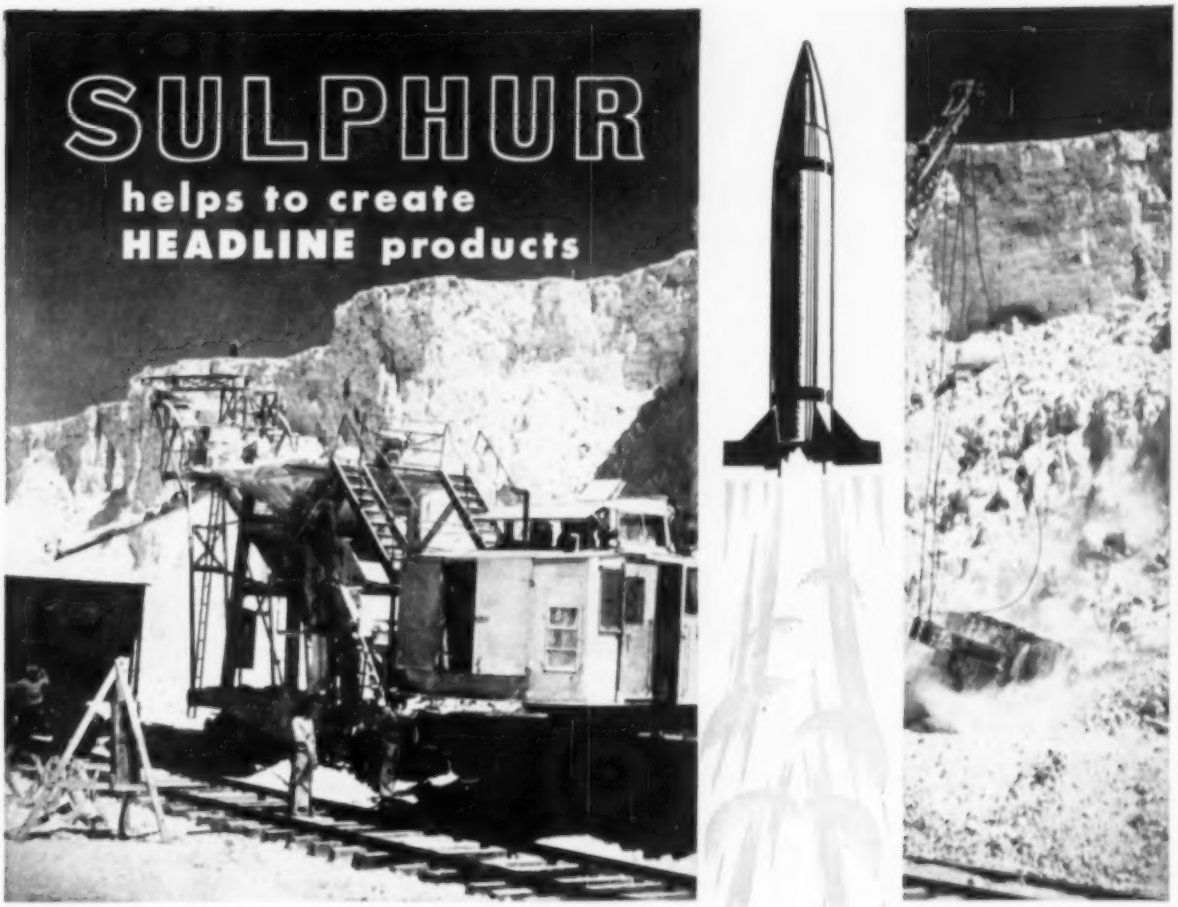
Production of polystyrene has begun at the new Kawasaki plant of Asahi-Dow Ltd. The new plant of the Asahi Chemical Industry-Dow Chemical Co. subsidiary received its first shipment of styrene monomer in January from Dow. □

The new catalytic process for making rigid polyethylene developed by Phillips Petroleum has been licensed to Industrias Quimicas Eletro Cloro, S.A. for use in Brazil and to Showa Denko K.K. of Japan. The Brazilian subsidiary of Solvay et Cie. will have exclusive use of the process in Brazil, Showa Denko will have same rights for Japan. □

A 2-million-volt Van de Graaff accelerator has been purchased from High Voltage Engineering Co. by Compagnie Francaise de Raffinage, leading French petroleum refining and processing organization. The accelerator will be used in fundamental research relating to the effect of radiation on the organization's line of petroleum products. □



The Anaconda Company's subsidiary, Andes Copper Mining Co., has outlined a new, expanded plan for mining and beneficiating the copper ores of its new El Salvador Mine project in Chile. Under provisions of Chile's new copper law, the plan, if approved, will result in investment of a total of $80,150,000. In this picture a drilling rig is in operation.



Thiokol®

"Thiokol" synthetic rubber, is an organic polysulfide elastomer. One of its many uses is in solid propellents for long range and high altitude missiles. In liquid form, "Thiokol" synthetic rubber mixed with an oxidizer, is poured into specially designed combustion chambers of rockets. It helps to give stability to the fuel charge and resistance to shock. It promotes uniform burning. When the rocket motor is ignited the mixture burns with great intensity and generates large volumes of gas to propel the rocket.

Solid propellents made with "Thiokol" synthetic rubber have proved their value in rockets over liquid propellents in many ways: they are less costly and easier to manufacture—simple and rugged construction makes handling and launching easier and safer—fuel tanks and complicated feed systems are eliminated.

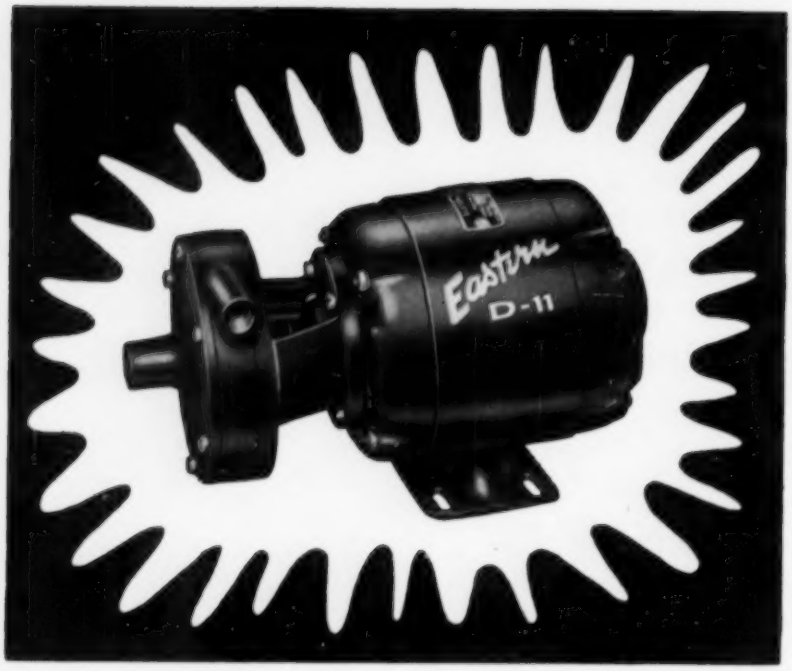
"Thiokol" synthetic rubber is a product containing a high percentage of Sulphur—its name being derived from the Greek words for sulphur and glue. Here is another example of the continually broadening field in which Sulphur is an important and necessary element.

**A trade name of Thiokol Chemical Corporation.*

Texas Gulf Sulphur Co.

75 East 45th Street, New York 17, N. Y.
811 Rusk Avenue, Houston 2, Texas

Sulphur Producing Units
- Newgulf, Texas
- Moss Bluff, Texas
- Spindletop, Texas
- Worland, Wyoming



24,830 successful installations!

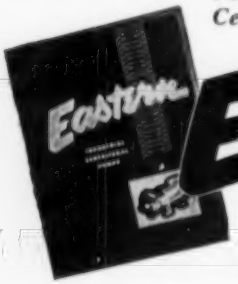
EASTERN D-11 CENTRIFUGAL PUMP

Why is the D-11 so successful among original equipment manufacturers? *Size and weight* make it ideal. The D-11 is the smallest, close-coupled, single-stage centrifugal pump available with an induction type motor. Eighteen pounds of compact design (9¾" x 4⅝") make it excel in industrial and process equipment, as well as laboratory service, and pilot plant operations.

SPECIAL METALS

A full selection of metals make the D-11 and other Eastern Centrifugal Pumps versatile performers. Available in 18-8 Type 303 and Type 316 Stainless Steel, Monel, Hastelloy "C", Cast Iron and Bronze, Eastern Pumps range from ⅛th to ¾ H.P. with capacities up to 70 G.P.M., pressures to 65 P.S.I.

For complete specifications on all Eastern Centrifugal Pumps, request Bulletin 120-A



Eastern INDUSTRIES, INC.
100 Skiff St., Hamden 14, Conn.

OVERSEAS NEWS

A plant to manufacture fatty acids and their derivatives will be built in Brussels, Belgium, by a new company, Oleochim, S.A. The new firm is jointly owned by Archer-Daniels-Midland and Palmafina, a wholly-owned fats and oils processing subsidiary of the giant Petrofina company. The plant will be operated by Palmafina. □

Chemical Construction Co. is designing a new ammonia plant for Asahi Chemical Industry Co., Ltd., of Japan. Capacity of the new plant will be 50 metric tons a day. Process used will be the Texaco oil gasification process. □

A $6 million contract for engineering and design work at the Esso Standard Refinery, S.A. plant at Antwerp, Belgium, has been awarded to newly-merged Badger-Comprimo N.V. of The Hague, Neth., subsidiary of Badger Mfg. Co. and Comprimo, N.V., of Amsterdam. □

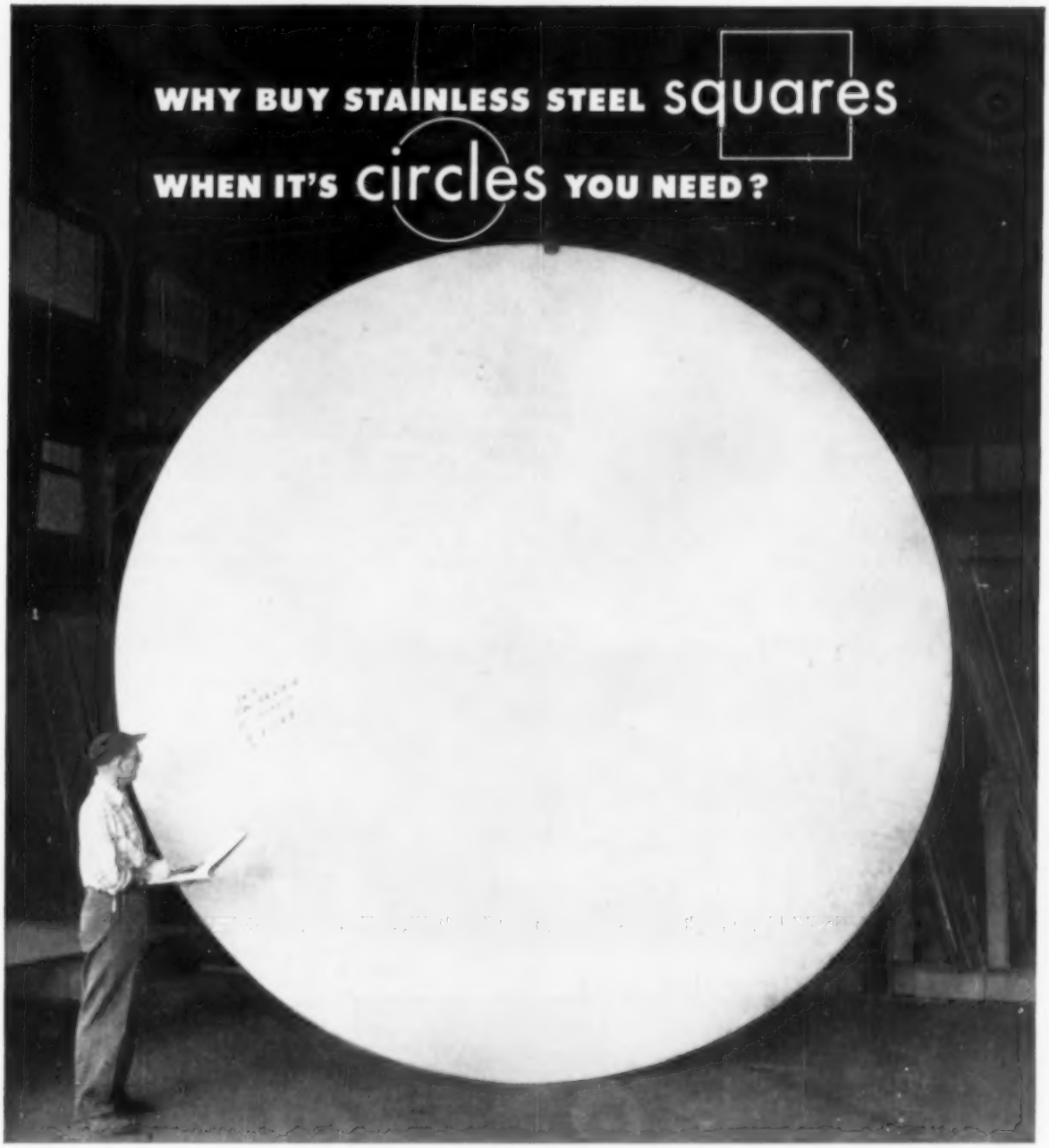
New plant for the manufacture of formaldehyde and the formulation of synthetic resins derived from formaldehyde, is under construction by Celanese Mexicana, S.A., an affiliate of Celanese Corp., at San Cristobal Ecatepec, 12 miles north of Mexico City. □

New polymerization plant is being built at Slough, England, by National Adhesives, Ltd., the English affiliate of National Starch Products. Production will include polymers of vinyl acetate and formulated resin adhesives. □

A new ammonia plant will be designed for Befu Chemical Co., Ltd., of Japan by Chemical Construction Corp. The Texaco partial oxidation process will be used, capacity can go to 100 tons a day. □

A $2 million plant to manufacture soaps and detergents has been built in Malines, Belgium, by Procter & Gamble. Construction was handled by H. K. Ferguson Co. of Belgium, S. A.

WHY BUY STAINLESS STEEL squares WHEN IT'S circles YOU NEED?



This circle, 9/16" thick x 164" diameter, is one piece of Type 316L stainless steel. Had the customer ordered a square, he would have paid freight on a half-ton of excess material. Also, he would have had the problem and expense of handling the square and cutting the circle.

Here are four sound reasons why Carlson customers save time and money when they order the circles they want—rather than the squares they have to cut . . .

1. If the gauge and size are circle-shearable, there is no extra charge for cutting the circle. This saves cutting labor and scrap handling expense.
2. If the gauge is such that a cutting charge applies to the square, it pays to order the circle. This eliminates the extra charge for cutting the original square and involves only the one charge for cutting the circle.
3. Because circles weigh approximately 25% less than squares, there's a substantial saving in transportation costs.
4. Small or medium size circles are often available from stock when squares may not be. The delivery time saved can be an important factor.

When you need stainless steel circles, come to Carlson where we specialize in stainless steel . . . that's your guarantee of dependable service.

Stainless Steels Exclusively

R. C. CARLSON Inc.

THORNDALE, PENNSYLVANIA

District Sales Offices in Principal Cities

Plates • Plate Products • Forgings • Bars • Sheets (No. 1 Finish)

PARTIAL SHROUD IMPELLERS REDUCE THRUST LOAD

Chester McFarland | De Laval Steam Turbine Co., Trenton, New Jersey

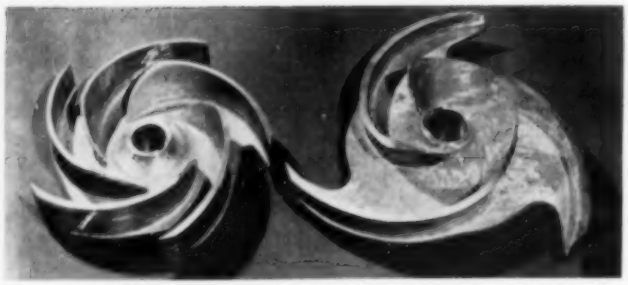


Fig. 1. Single suction impellers with some of the rear shroud area removed.

Consistent results obtained from tests of partial shrouds on De Laval process pumps have revealed that thrust loads can be cut approximately 35 per cent for operating conditions at or near shut-off. In turn, this reduction of thrust load reduces the possibility of thrust bearing failure when operation near the shut-off condition is frequent or continuous.

Process pumps in particular, are subject to this method of operation. Many processes are essentially "batch" operations and, if these batches are run close enough together, a desirable "continuous" operation is approached. For the convenience of the operating personnel, pumps used with such a system are often allowed to run at shut-off between batches.

An accumulation of safety factors in selecting the intended operating point can also result in operation close to shut-off. Since most process fluids have not been tested for friction flow characteristics as thoroughly as has water, calculations of friction loss are not as accurate as those for water. In addition, process pumps are production rather than maintenance equipment and future growth of production quotas is often considered in selecting the design point.

When a pump is first laid out on the designer's board, he has preselected some commonly desired design point and has calculated the throat, eye and nozzle areas, the impeller vane width and the tip width, etc., all in accord with this preselected design point. Shaft strength and bearing design are based primarily on this design point, with suitable safety factors for infrequent operation at shut-off. In operation, reasonable deviation from this design point is allowed. An operating point far beyond the design point will force too much volume through the pre-determined areas. Resulting velocities are higher than desirable. This creates noise and cavitation. On the other hand, operation at reduced capacity at or near shut-off pressure creates additional axial and radial thrust loads, both being functions of pressure and of the projected areas upon which the pressure acts.

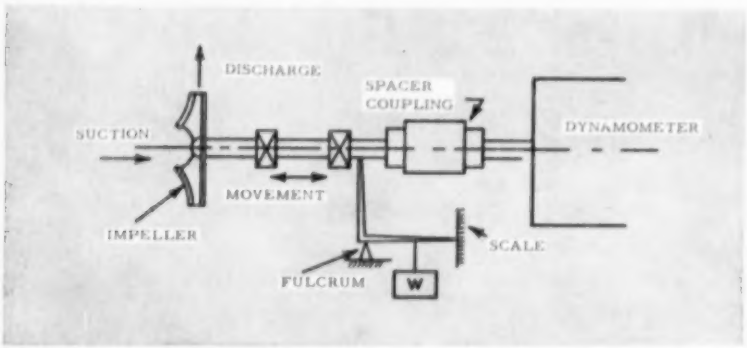


Fig. 2.

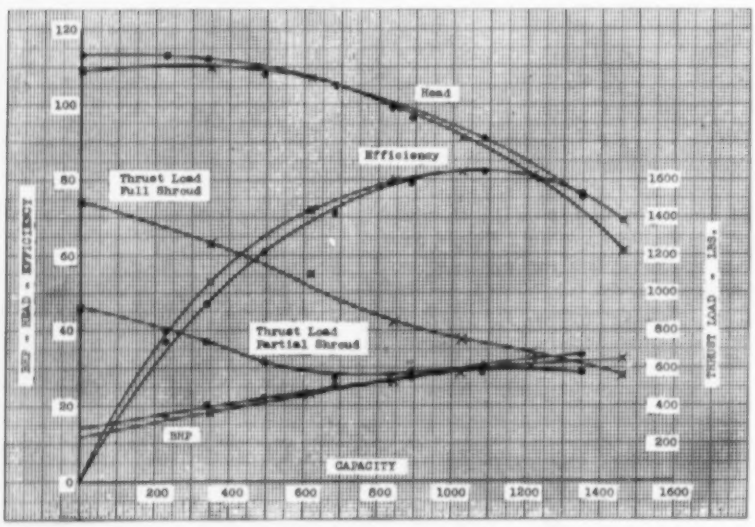


Fig. 3.

While these loads are present throughout the range of the pump, they are exaggerated at reduced capacity. There are several methods by which the designer can offset or reduce these forces or their effects. The volute translates into pressure energy the velocity imparted by the impeller to the fluid. The pressure increases gradually from the "cut-water" or tongue around the volute to the throat through which the fluid escapes. The unbalanced pressures constitute a force in a radial direction which causes shaft deflection. Mounting the impeller between bearings and increasing the shaft diameter will give greater shaft stiffness to resist deflection. A double volute design can be obtained by locating a second tongue 180° around the volute from the first to provide balanced pressures.

Thrust in the axial direction arises from an unbalance of discharge pressure acting in one direction and suction pressure acting in the other. A double-suction impeller, with its in-

(*Continued on page* 110)

Fairbanks-Morse fire pumps provide 12,000 gpm. of water at 100 psi. for each of two systems.

World's largest jet aircraft center protected by F-M fire pumps

Four major aircraft companies—Lockheed, North American, Convair and Northrop—use the 5000-acre U. S. Air Force Plant No. 52 at Palmdale, Calif., for assembly and testing.

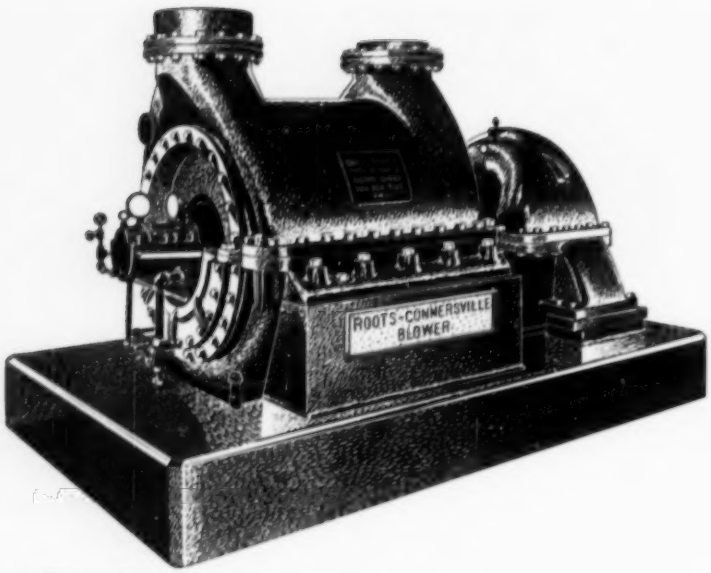
Maximum protection against fire at this gigantic operation was achieved at minimum cost by installing two identical, interlocking water supply systems, each equipped with Fairbanks-Morse pumps for both water supply and sprinkler pressure.

The size and scope of this installation indicate Fairbanks-Morse's ability to supply fire pumps for all magnitudes of industrial and municipal requirements. Whatever your needs in fire protection—big installations or small—your Fairbanks-Morse Field Engineer will be glad to work with your own engineers, in specifying the most efficient equipment. Call him today, or write Fairbanks, Morse & Co., Dept. CEP-4, 600 So. Michigan Ave., Chicago 5, Ill.

FAIRBANKS-MORSE

a name worth remembering when you want the BEST

PUMPS • SCALES • DIESEL LOCOMOTIVES AND ENGINES • ELECTRICAL MACHINERY • RAIL CARS • HOME WATER SERVICE EQUIPMENT • MOWERS • MAGNETOS



R-C centrifugal blowers assure accurate control of volume and pressure

At any speed, Roots-Connersville centrifugal blowers assure uniform delivery of air or gas without the use of receivers. In matching supply to changing demand, this inherent operating advantage simplifies accurate and instantaneous control of volume and pressure.

R-C centrifugals may be direct-connected to high speed electric motors or turbines. Operating speeds may be further raised with speed increasing gears. Occupying a minimum of space and perfectly balanced, with semi-rigid bearing supports to dampen vibration, they do not require special, costly foundations.

Liberal design of diffuser and return passages results in low velocities, normal efficiency even when build-up occurs and exceptionally quiet operation. Operating without internal lubrication, oil-free air is discharged, making it ideally suited for exacting process applications. For complete specification details, write for Bulletin 120-B-14.

Engineers—unusual career opportunities await you at Roots-Connersville. Address your resume to Professional Employment Manager.

ROOTS-CONNERSVILLE BLOWER

A DIVISION OF DRESSER INDUSTRIES, INC.

457 Indiana Ave., Connersville, Indiana. In Canada—629 Adelaide St., W., Toronto, Ont.

SHROUD IMPELLERS

(*Continued from page* 108)

herent hydraulic balance at all points, is used in horizontally split case pumps and will largely overcome axial thrust. What thrust then remains is the result of uneven entry of the fluid into the two sides of the impeller. This residual thrust can be caused by poor piping arrangement or by nozzle casting variation.

With an end-suction overhung-impeller pump, the shaft can also be made heavier. This design requires a single-suction impeller and, therefore, unbalanced axial thrust is present in a direction toward the lower pressure suction side of the impeller. Considering that thrust force is essentially pressure multiplied by the area upon which it acts, some of the force can be eliminated by eliminating some of the area. (The shut-off pressure itself cannot be diminished without changing the design point pressure or altering the shape of the pump's characteristic curve). Figure 1 illustrates the single-suction open type of impeller with some of the rear shroud area removed.

Test Results

Tests were conducted on several end suction pump designs all having one common feature—the ability to adjust the rotor position axially. The rotors were allowed to position themselves while running and the axial movement was measured by linkage and graduated scale. (See Figure 2.)

The curves in Figure 3 are based on a 10½-in. O.D. impeller, running at 1,750 rev./min. Examination of the curves reveals the effects of the partial removal of shroud area. For each size tested, axial thrust at shut-off was reduced to approximately 65% of the former value. Calculations indicate that the life of the thrust bearing should be improved substantially over that to be expected when the bearing is subjected to the former thrust load. At full capacity, where the designer's velocities and volumes are more nearly those planned originally, the partial shrouds do not affect the thrust load as drastically. At this point, the load approaches the value that would be obtained with full shrouds.

Partial removal of the shroud gives slightly less guidance to the fluid as it leaves the impeller. Efficiency at reduced capacities is lowered slightly. However, process pumps are usually of low power rating and the difference in efficiency is negligible, particularly when balanced against increased reliability and adaptability to process applications.

INSTITUTIONAL NEWS

Win $500 with a symbol—a slogan! 1958 is Fiftieth Anniversary year for A.I.Ch.E. High-point of this chemical engineering landmark will be the week-long meeting in Philadelphia June 22 through 27. Special volumes are in progress on the many facets of chemical engineering, speakers are preparing speeches—and the Institute wants a new symbol and a new slogan which could characterize chemical engineering.

Therefore, the Institute is running a contest. For the best slogan—$250! For the best symbol—$250! The rules are simple:

1) Entries must be submitted to: American Institute of Chemical Engineers, 50th Anniversary Contest, 25 W. 45th St., New York 36, N. Y.

2) All entries must be postmarked no later than June 30, 1957.

3) More than one entry may be submitted.

4) Entries will not be returned.

5) Decisions of the judges will be final.

6) The winner of each contest, decided by the 50th Anniversary Committee, will receive $250.

7) Both slogan and symbol must be distinctive and original.

8) The first entry received will be used in case of similarity or duplication in design or wording.

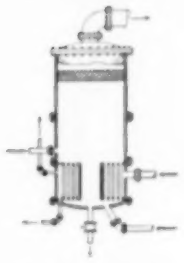
9) A committee of past presidents to serve as judges will be appointed by the 50th Anniversary Committee. □

The papers presented at the Second EJC Nuclear Congress in Philadelphia March 11-15 have been published, and are now available, together with the papers from the Hot Laboratories and Equipment Conference held concurrently. Priced at $0.30 each, the official list and order form can be obtained from the American Society of Mechanical Engineers, Order Department, 29 West 39th Street, New York 18, N. Y. □

AEC will provide $9,650 to continue the support of research on mass transfer in packed columns at Clarkson Tech during 1957. Results of these investigations so far have been published in the *A.I.Ch.E. Journal* in four papers. □

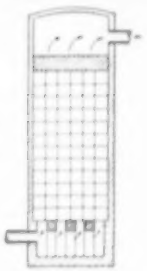
A subcommittee of A.I.Ch.E.'s 50th Anniversary Committee, under B. F. Dodge, is planning for participation of foreign engineers in the 50th Anniversary celebration. Dodge needs help from members for: 1) names of distinguished foreign industrial chemists and chemical engineers who might participate in the technical programs; 2) authors for the articles in the booklet "Chemical Engineering Around the World." □

For Complete Liquid-Vapor Separation
Use METEX Mist Eliminators!



in VERTICAL TUBE EVAPORATORS

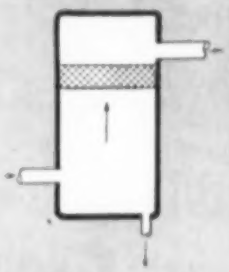
100% removal efficiency at all normal vapor velocities traps entrained contaminants below gas outlet — prevents carry-over of undesirable liquid particles.



in PACKED COLUMNS

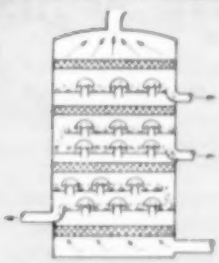
Liquid particles, rising through the packing, are effectively trapped and returned by a METEX Mist Eliminator installed at the top of the column below the gas outlet.

METEX Mist Eliminators are recommended for use in all liquid-gas processing vessels to remove and return all entrained liquids with virtually 100% efficiency over a broad range of operating velocities. High, free volume assures negligible pressure drop, usually less than ½" of water. Modified knitted wire structure minimizes stagnation points for liquid build-up and assures rapid and complete drainage, even when solids are present.



in KNOCK-OUT DRUMS

Existing vessels can be operated at higher velocities with complete liquid removal. New vessels can be made smaller and will handle larger input.



in DISTILLATION COLUMNS

Used in fractionating columns, METEX Mist Eliminator can be placed above the feed inlet to remove and return impurities, or at any point of product removal where entrainment is critical for quality control.

METEX Mist Eliminators can be supplied in any required size or shape and can be fabricated of any desired metal or alloy (including some plastics) to resist varied corrosive conditions. Our engineers will be glad to recommend the type of Mist Eliminator and method of installation best suited to your individual operating conditions.

For complete information on METEX Mist Eliminators, write for Bulletin No. ME-6.

METEX QUALITY PRODUCTS

METAL TEXTILE CORPORATION

ROSELLE, NEW JERSEY

METAL TEXTILE CORP. of Canada, Ltd., Hamilton, Ontario

REPRESENTATIVES IN PRINCIPAL CITIES THROUGHOUT THE WORLD

6-164

CANADA DRY

"CANADA DRY BEVERAGES CHOOSE E-D FILTER PAPERS TO GET SPARKLE AND PURITY!"

J. L. Murphy, Jr., Vice-President in charge of production for Canada Dry Ginger Ale, Inc.

"For 30 years, we have used Eaton-Dikeman filter papers to obtain the sparkle and purity that are essential in maintaining the quality for which Canada Dry Beverages are known and liked", says Mr. J. L. Murphy.

"Our beverages are sold to millions of consumers each year. They are a discriminating and exacting jury. Clarity, flavor, sparkle must be up to top standards at all times to hold their loyalty. Thus, in the final stages of polish filtration, we must have a *dependable* and *uniform* filter medium. We have found that Eaton-Dikeman filter paper, year in and year out, fulfills these requirements.

"In addition to fine porosity, E-D filter paper has very high rapidity, which is a requisite for maintaining the high production rate of Canada Dry Beverages.

"Filtration is a very important part of our operation. Every bottle that leaves our plant must be sparkling, clear and pure. E-D filter paper helps us uphold these standards."

To get maximum clarity for *your* filtration, let us recommend the grade you ought to try. E-D samples for test runs gladly furnished without obligation.

E D *The Eaton-Dikeman Company*

FILTERTOWN
MOUNT HOLLY SPRINGS, PENNSYLVANIA

FUTURE MEETINGS and Symposia of the Institute

View of Seattle from Queen Anne Hill, Mt. Rainier in background.

MEETINGS **SYMPOSIA**

■ **SEATTLE, WASH.** June 9-12, 1957. Olympic Hotel. See page 80 for complete meeting program.

■ **ST. LOUIS**

June 2-6, 1957. Jefferson Hotel.

Golden Anniversary Meeting. Air Pollution Control Association; sponsoring societies include A.I.Ch.E. (Tuesday, June 4 will be A.I.Ch.E. day.)

Methods of Analysis; Instrumentation; Atmospheric Reactions; Photochemical & Other; Aerosol Formation & Control; Progress in Air Pollution Control Equipment & Methods; and Human & Economic Goals for Engineers in Air Pollution Control will be treated.

For information contact W. L. Faith, Managing Director, Air Pollution Foundation, 704 S. Spring St., Los Angeles 14, California.

■ **PASADENA, CALIF.**

June 19-21, 1957. California Institute of Technology.

The 1957 Heat Transfer and Fluid Mechanics Institute. A.I.Ch.E. is one of the sponsoring societies. Papers on technical and scientific advances in fluid mechanics, heat transfer, thermodynamics, and related fields.

GENERAL CHAIRMAN: Peter P. Wegener, Jet Propulsion Laboratory, Calif. Inst. of Tech., 4800 Oak Grove Drive, Pasadena 3, Calif.

■ **STATE COLLEGE, PA.**

August 11-14, 1957. Pennsylvania State University.

First National Conference on Heat Transfer, featuring Applied Heat Transfer. Sponsors: A.I.Ch.E., A.S.M.E., & College of Eng. & Arch., Penn State Univ.

James N. Addoms, Atlas Powder Co., Wilmington 2, Delaware, is A.I.Ch.E. program chairman.

■ **BALTIMORE, MD.**

September 15-18, 1957. Lord Baltimore Hotel.

TECHNICAL PROGRAM CHAIRMAN: R. L. Copson, Mutual Chemical Co. of America 1348 Block St., Baltimore 31, Maryland.

Adsorption, Dialysis, and Ion Exchange

CHAIRMAN: G. P. Monet, Du Pont, Wilmington, Delaware.

Intended to furnish basic information for chemical engineers working on mass separation problems.

Jet Propulsion

CHAIRMAN: C. E. Marsel, College of Eng., N.Y.U., University Heights, New York City 53.

The Alkali-Chlorine Industry

CHAIRMAN: Herman W. Zabel, Roger Williams, Inc., P. O. Box 426, Princeton, New Jersey.

Drying

CHAIRMAN: Ralph E. Peck, Chem. Engineering Dept., Ill. Inst. of Tech., Chicago 16, Ill.

Low Temperature Processing

CHAIRMAN: Clyde McKinley, Air Products, Inc., P. O. Box 538, Allentown, Pa.

Direct Operating Labor Costs

CHAIRMAN: John Happel, Chem. Eng. Dept., New York University, University Heights, N. Y. 53.

Air Plant Safety

CHAIRMAN: N. H. Walton, Atlantic Refining Co., 3144 Passyunk Avenue, Philadelphia 1, Pa.

Ammonia Plant Safety

CHAIRMAN: Harold Maune, Mississippi River Chemical Co., Crystal City, Missouri.

Statistics in Chemical Engineering

CHAIRMAN: To be named.

■ **ANNUAL—CHICAGO, ILL.**

December 8-11, 1957. Conrad Hilton Hotel

TECHNICAL PROGRAM CHAIRMAN: Henry F. Nolting, Standard Oil Co., 2400 New York Ave., Whiting, Ind.

Fluidization of Solids

CHAIRMAN: E. R. Gilliland, Chem. Eng. Dept., M.I.T., 77 Massachusetts Ave., Cambridge 39, Mass.

Covering two main areas: the characteristics of solid and gas flow in beds of fluidized solids; the characteristics and relative effectiveness of fluidized and fixed beds as chemical reactors.

Effective Cost Control in Process Operations

CHAIRMAN: C. W. Nofsinger, The C. W. Nofsinger Co., 906 Grand Ave., Kansas City 6, Mo.

Evaluation of Projects from the Original Idea to the Investment Stage

CHAIRMAN: C. W. Nofsinger (see above).

Chemical Engineering Abroad

CHAIRMAN: Shelby Miller, Chem. Eng. Dept., University of Rochester, River Campus Station, Rochester 20, N. Y.

Corrosion Resistant Alloy Materials of Construction

CHAIRMAN: G. Fred Ours, Carbide and Carbon, Charleston, W. Va.

Laboratory and Pilot Plant Techniques

CHAIRMAN: G. W. Blum, The Goodyear Tire & Rubber Co., 1485 E. Archwood Ave., Akron 16, Ohio.

Radiation Processing

CHAIRMAN: J. J. Martin, Dept. of Chem. Eng., Univ. of Michigan, Ann Arbor, Michigan.

Nuclear Process-Heat and Radiation Source Reactor Systems for the Chemical and Metallurgical Industries

CHAIRMAN: B. W. Gamson, Borg-Warner Corporation, Des Plaines, Illinois.

Extractive Metallurgy

CHAIRMAN: B. W. Gamson (see address above).

Selling a Technical Program

CHAIRMAN: W. L. Bulkley, Standard Oil Company (Ind.), Whiting, Indiana.

Shock-Wave Concept of Equipment Design

CHAIRMAN: Stuart Churchill, Dept. of Chem. Eng., Univ. of Michigan, Ann Arbor, Michigan.

Use of Computers in the Chemical Industry

CHAIRMAN: Leon Cooper, Monsanto Chemical Company, St. Louis, Missouri.

(Continued on page 114)

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FUTURE MEETINGS

(*Continued from page 113*)

MEETINGS **SYMPOSIA**

Special Techniques for Separation and Recovery of Biochemical Materials

CHAIRMAN: Elmer Gaden, Dept. of Chem. Eng., Columbia University, New York City.

Chemicals Recovery in the Paper Industry

CHAIRMAN: R. P. Whitney, Inst. of Paper Chemistry, Appleton, Wisconsin.

Process Application of Reactors

CHAIRMAN: J. J. Martin, Univ. of Michigan, Dept. of Eng., Ann Arbor, Michigan.

1958 MEETINGS

- Montreal, Canada, April 20-23, 1958. Sheraton-Royal Hotel. Joint A.I.Ch.E.-C.I.C. Conference. A.I.Ch.E. CHAIRMAN: Kenneth Beatty, North Carolina State College, Raleigh, N. C. **Natural Uranium-Heavy Water Reactors and Their Fuel Cycles.** Chairman to be named.
- Philadelphia, Pa. June 22-27, 1958. Bellevue-Stratford Hotel. A.I.Ch.E. Fiftieth Anniversary Meeting. CHAIRMAN: Roy Kinckiner, DuPont, Wilmington, Del.
- August 18-21, 1958. A.I.Ch.E.-A.S.M.E. Heat Transfer Conference. CHAIRMAN: A. S. Foust, Dept. of Chem. Eng., Lehigh University, Bethlehem, Pa.
- Salt Lake City, Utah, September 21-24, 1958. CHAIRMAN: E. B. Christiansen, Dept. of Chem. Eng., Bldg. 437, Univ. of Utah, Salt Lake City. **Air Pollution.** CHAIRMAN: W. L. Faith, Air Pollution Foundation, 704 S. Spring St., Los Angeles 14, California.
- Cincinnati, Ohio, December 7-10, 1958. Netherland Plaza Hotel. A.I.Ch.E. Annual Meeting. **Water Pollution.** Chairman to be named. **Distillation.** CHAIRMAN: W. C. Schreiner, M. W. Kellogg Co., 711 Third Ave., New York City 17, N. Y.

UNSCHEDULED SYMPOSIA

Correspondence on proposed papers is invited. Address communications to the Program Chairman listed with each symposium below.

- **Centrifugation:** James O. Maloney, Dept. of Chem. Eng., U. of Kansas, Lawrence, Kans. The theory and quantitative aspects of centrifugation.
- **Size Reduction:** Edgar L. Piret, Chem. Eng. Dept., U. of Minnesota, Minneapolis 14, Minn.
- **Filtration & Centrifugation:** Horace Hinds, Jr., Corn Products Refining Co., Box 345, Argo, Ill.
- **Chemical Engineering Process Dynamics as They Affect Automatic Control:** David M. Boyd, 315 Ridge Ave., Clarendon Hills, Ill.
- **Ethylene Manufacture:** Hermann C. Schutt, 201 Devonshire St., Boston 10, Mass.
- **Dry Classification of Solids:** D. W. Oakley, Metal & Thermit Corp., Carteret, N. J.
- **Statistics in Chemical Engineering:** John C. Whitwell, Princeton University, Princeton, N. J.
- **Education of Chemical Engineers:** F. M. Tiller, Dean of Eng., University of Houston, Cullen Blvd., Houston 4, Texas.
- **New Chemical Engineering Construction Techniques:** S. A. Guerrieri, The Lummus Co., 385 Madison Ave., N. Y. 17.
- **Mineral Process Engineering and Mineral Economics:** L. A. Roe, International Minerals & Chemical Corp., 20 North Wacker Drive, Chicago 6, Ill.
- **Foams and Froths:** J. L. York, Dept. of

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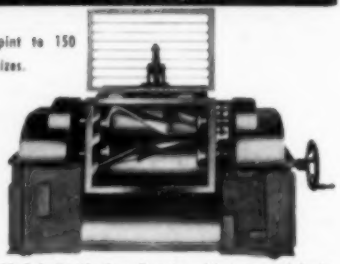

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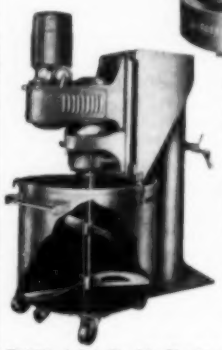

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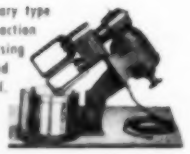

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Chem. & Met. Eng., Univ. of Mich., Ann Arbor, Michigan.

- **The Threatened Imbalance Between Chlorine and Alkali in American Chemical Industry:** Zola G. Deutsch, Deutsch & Loonam, 70 E. 45th St., New York City 17.
- **Shock Waves in Process Equipment:** Chairman to be named.
- **Scale-Up Philosophy in the Chemical Industry:** David B. Coghlan, Foote Mineral Co., Box 576, Berwyn, Pa.
- **Start-Up of New Chemical Plants:** M. L. Nadler, Du Pont, Wilmington, Del.
- **Computers in Optimum Design of Process Equipment:** Chen-Jung Huang, Dept. of Chem. Eng., Univ. of Houston, Cullen Blvd., Houston 4, Texas.
- **Kinetics & Rate Processes:** H. E. Hoelscher, Johns-Hopkins University, Baltimore, Md.
- **Financing for the Chemical Industry:** Bernard Stott, First National City Bank of New York City, New York, N. Y.
- **Chemical Engineers in Chemical Industry Management:** T. P. Forbath, American Cyanamid Co., 488 Madison Ave., New York, N. Y.
- **Training on the Job for Industry:** John Happel, Dept. of Chem. Eng., N. Y. University, University Heights, New York 53, N. Y.
- **High-Speed and Time-Lapse Photography in Chemical Engineering:** J. W. Westwater, Dept. of Chem. Eng., 205 East Chem. Bldg., Univ. of Illinois, Urbana, Ill.

LOCAL SECTION MEETINGS

■ AKRON—CINCINNATI—CLEVELAND—PITTSBURGH—TOLEDO—CENTRAL OHIO

May 10, 1957. Joint one-day regional symposium on "Industrial Pollution Control," Sheraton-Mayflower Hotel, Akron, Ohio. Reservations and pre-registration: H. H. Baker, White Industrial Sales Co., 2nd National Bldg., Akron, Ohio. Cost: $1.00—student members; $2.00—A.I.Ch.E. members; $3.00—non members.

A.M., Air Pollution: "Some New Engineering Tools and Techniques for Cleaner Air," O. C. Thompson, Carbide & Carbon, and G. W. Blum, Goodyear. "Venturi Scrubbers in Odor Control," J. F. Byrd and E. L. Dewey, Procter & Gamble. "Catalytic Fume Combustion for Chemical Manufacturing Processes," R. J. Ruff, Catalytic Combustion Corp.

P.M., Stream Pollution: "Purify While They Cool," E. Mohler, Sun Oil. "Observations of the Behavior of Mineral Oil as a Water Pollutant," F. J. Ludzack, chemist, and R. A. Taft, Sanitary Engineering Center. "Economic Considerations in the Disposal of Spent Pickle Liquor and Plating Wastes," C. A. Snavely and J. E. Clifford, Battelle. "Reduction of B.O.D. from Neutral Sulfite Waste-Liquor Stream by Evaporation and Burning," H. E. Templeton, Vulcan-Cincinnati.

■ NEW JERSEY

May 14, 1957. Eighth Annual 1-day meeting, Military Park Hotel, 16 Park Place, Newark, New Jersey.

PROGRAM CHAIRMAN: L. Ferrise, Merck & Company, Rahway, New Jersey.

P.M., General Session (simultaneous with Technical Session), "The Engineer as a Professional Man"; "His Society," F. J. Van Antwerpen, A.I.Ch.E.; "His Job," C. F. Savage, General Electric; "His Pay," H. L. Rusch, Opinion Research Corporation.

Technical Session (simultaneous with General Session), "Unit Processes—Latest Techniques"; "Chlorination," R. B. MacMullin, MacMullin Associates; "Alkylation," W. F. Rollman, Esso Research; "Sulfonation and Sulfation," E. E. Gilbert, General Chemical Research Labs; "Hydrogenation," S. Milazzo, E. F. Drew Co.

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News of the Field
FROM LOCAL SECTIONS

TWO LOCAL SECTIONS HONOR PAST CHAIRMEN

Certificates of recognition are presented to past chairmen of the National Capital and Akron Sections at local meetings.

On hand to honor the past chairmen of the **National Capital Section** at the section's March meeting was national A.I.Ch.E. president J. Henry Rushton. In addition to the featured speech of the evening, on Mixing, Rushton presented the recognition certificates, section chairman pins, and engraved, plastic-faced stainless steel gavels to ten past chairmen: R. S. McBride; J. T. Cox, Jr.; P. H. Groggins; G. Armistead, Jr.; R. D. Sheeline; W. T. Read; D. O. Myatt; M. T. Bennett; A. C. Scurlock; and J. L. Gillman, Jr.

At the **Akron Section** meeting in January, it was present chairman T. H. Rogers who presented the certificates of recognition to 18 past chairmen: H. L. Trumbull; R. P. Dinsmore; J. W. Street; J. P. Maider (deceased); W. I. Burt; A. L. Mohler (deceased); M. A. Knight, Jr.; G. R. Lyon; C. B. Cooper; I. D. Patterson; P. G. McDermott; L. Freeman; R. C. Stell; J. Kosko; A. B. Japs; P. M. Lindstedt; W. M. Otto; and H. Baker.

Past chairmen present in person at National Capital meeting pictured with Rushton. L. to r., Groggins, Read, Armistead, Rushton, McBride, Myatt, and Gillman.

The Akron meeting continued after the presentations with a consideration of the problems now existing in the communication of ideas. G. R. Cowan, industrial engineer of B. F. Goodrich, in his speech on Human Engineering Applied to Large Business, presented a practical and proven method of getting results in communication by use of Group Problem Solving Conferences.

—D. O. Myatt
—E. W. Campbell

PLANS PROPOSED FOR EDUCATING TOMORROW'S ENGINEERS

In a joint meeting with other local engineering societies, the Savannah River Section held a major session on the problems of engineering education as part of its National Engineering Week celebration.

In covering the needs of industry for engineers, and the factors affecting the production of good engineers by the engineering colleges and universities, Jesse E. Mason, dean of the School of Engineering, Georgia Institute of Technology, speaking at **Savannah River Section's** joint meeting with other engineering groups in February, cited two major factors affecting the number and quality of good engineering graduates. First, the condition of physical plants at the various educational institutions. Second, the present

(Continued on page 118)

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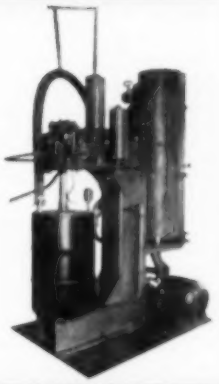

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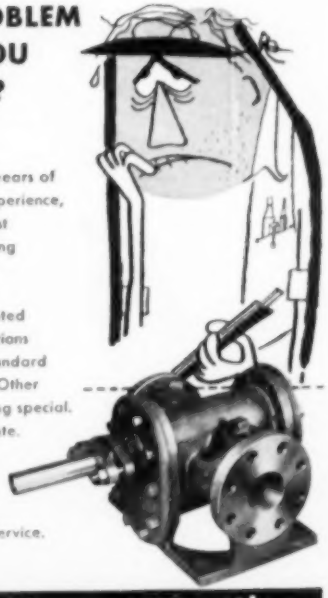

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KNIGHT-WARE CHEMICAL EQUIPMENT

News of the Field
FROM LOCAL SECTIONS

(Continued from page 116)

great lack of good and inspiring teachers of mathematics and basic science in the secondary schools.

As far as the needs of industry are concerned, Mason emphasized that the fact that graduating seniors get offers from 15 to 20 companies does not mean that there is need for 15 to 20 times as many engineers as we are graduating, in fact he felt that the needs of industry are in closer balance with the graduating classes than is admitted. Industry could probably fill all its needs by utilizing the engineers it has on engineering work instead of in sales or management or any of the other areas engineers are now in.

Many plans have been suggested to alleviate the present apparent shortage of good graduating engineers, but there are drawbacks to most of them. Perhaps the best, Mason pointed out, is the so-called 3-2 plan. This is the program which has a student take three years at a liberal arts college and two years following at an engineering school. The student gets a degree from both schools, is certainly a better-rounded engineer when he graduates. While this plan has the drawback of costing the student more money, it has the advantage of turning out better students and doubling the physical plant of the engineering schools.

Increasing the present curriculum to five years at an engineering school certainly could turn out better students but it would cost the student more and actually lower the physical plant capacities of the engineering schools. Economic considerations are also the drawback to the idea of "pre-professional" training in the manner of medical doctors.

Based on the present situation in industry, where too often graduate engineers are doing what is essentially little more than technician's work, Mason described the growing idea of providing Technical Schools where technicians can be trained to do the highly important jobs in industry that call for considerable technical training and ability but do not call for the theoretical and full-engineering training of the graduate engineer.

In conclusion, Mason pointed strongly to one of the weakest points in present engineering education—the secondary schools. "The trend has been to be bored with basic science and mathematics in secondary school, to go to college, and to return to

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secondary schools to teach the next generation to be bored with basic science and mathematics." There is a crying need for good secondary school teachers, the societies can help by having their members teach in spare time, and summer employment of secondary school teachers has been and will continue to be helpful in solving this most acute long-term problem.

—*R. O. Pekkala*

INVESTMENT, SAFETY IN PLANTS, TECHNICAL SUBJECTS AT LOCAL SECTION MEETINGS

At the **Maryland Section's** (*P. Mexsina*) March meeting, C. P. Neidig, a general partner of White, Weld & Co., stated that in the chemical industries internally generated funds are the main sources of capital for expansion. These internal funds are developed from retained earnings or depreciation accounts. In the chemical industries the overall depreciation rate is 7%, and certificates of necessity issued during the Korean action have increased this to 20% in some cases. The Government is now permitting the use of the "declining balance" or "sum of digits" for determining depreciation allowances and both methods permit a high return in the early stages of a venture. But while internal capital is most common, some of the larger chemical companies can use external funds profitably. If they have outstanding records they can issue 100 year indentures without any sinking fund or direct repayment features.

Turning to the other side of the investment picture, Charles Westheimer, of Westheimer and Co., and Francis Williams, investment com-

(*Continued on page* 120)

National A.I.Ch.E. president J. Henry Rushton here is emphasizing the importance of the individual chemical engineer to the industry in a speech on "Chemical Engineering—Your Lifetime Profession" to the February meeting of the Rochester Section (*F. L. Wells*). Rushton went on to explain how the Institute can help the individual engineer by stimulating his interest through publications, meetings, promoting personal contacts, and providing an impetus for community service. But, Rushton reiterated, it is the support of the individual chemical engineer that is the backbone of the industry and of the society.

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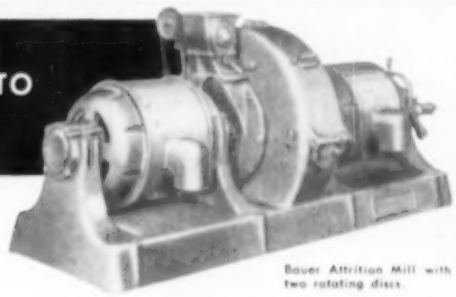

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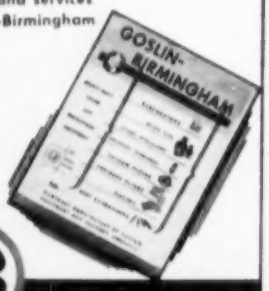

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A.I.Ch.E News of the Field

FROM LOCAL SECTIONS

(Continued form page 119)

selor to the Chemical Fund, pointed out the advantages of investing in the chemical industry to the February meeting of the **Ohio Valley Section** (*K. Ericson*). In general, chemical stocks are attractive buys for the investor because of their high ratio of earnings to share value, indicating undervaluation of the stock based on capital investment. But, both speakers emphasized, investments in the chemical field presumed a knowledge of the potential of existing or prospective products or processes, and that without such knowledge profitable investment is a matter of chance.

Plant Safety

A. Dunlap, safety director of Carbide & Carbon Chemicals, speaking to the February meeting of the **Charleston (W. Va.) Section** (*J. R. McClain*), outlined four problems involved in effectively fighting a large fire: 1) defining emergency areas; 2) road blocks by police; 3) suffocation in fire areas; and 4) radiant heat effect on nearby facilities. Dunlap also emphasized the importance of automatic fixed protection systems to prevent fire outbreak and spread.

Turning more technical, the January meeting of the **East Tennessee Section** (*A. J. Peacock, Jr.*) heard S. C. Colbeck, Pittsburgh Coke and Chemical, present a detailed talk on "Behavior of Granulated Carbon in Columns for Gas-Phase and Liquid-Phase Applications." High surface area is the prime consideration in adsorption and in activated carbon the smaller pore size, or micropore system, accounts for nearly all the surface available for adsorption. But since strong adsorption is also associated with high retentivity, a fine pored carbon may not be economically feasible in some cases for the recovery of solvent vapors. The efficiency of utilization of carbon in a column increases with increasing bed depth, with decreasing particle size, and with decreasing flow rate.

H. O. Ehrisman, Foxboro Co., continued his discussion of the Sales Engineer and how to evaluate his performance (*CEP*, January 1957) before the January meeting of the **Rhode Island Section** (*J. L. Campanella*). Although management does look for dollar volume, the performance of a sales engineer does not necessarily depend on this factor. Ac-

(Continued on next page)

DESIGNERS

WHERE do you start training for promotion from your first day on the job?

For the answer, turn to page 40.

VALUABLE TANK HEATING DEVELOPMENT

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tually, the selling time of a sales engineer can be as little as 25% of his time, with the remainder spent on specifications, drawings, explanations, training, travelling, and other necessary preparations.

New Club

With 47 prospective members present at its first dinner meeting in January, the process of organizing a new club of chemical engineers in **Indianapolis,** Ind., is well underway. With its objective A.I.Ch.E. section status as soon as possible, the club invited A.I.Ch.E. national president Henry Rushton to be its first speaker.

The club has a committee of nine representing seven companies in the Indianapolis area.

Also Meeting

Industrial Development in Arkansas held the floor at the January meeting of the **El Dorado Section** (*G. D. Rucker*). Banker L. E. Hurley analyzed the state's problem of losing people to states where job opportunities are better, explained how Arkansas is trying to build up its industry, showed that a big hurdle is that Arkansas people do not like to pay taxes. This money problem is being worked on now, the state hopes to bring more and more industry to Arkansas. . . Last meeting of the year 1956 for the new **Southern Nevada Section** (*J. L. Pearson*) was held in December on the subject of Statistics—A Tool for Engineers. . . **The Ichthyologists (Boston Section)** (*J. S. Collins*) heard Gen. M. Ogden outline the history of anti-aircraft artillery from the first hand-held pistol to the modern Nike missile. . . L. W. Bass, Arthur D. Little, Inc., spoke to the **Detroit Section** in January on the subject of his experiences working on the industrialization of Egypt and Iraq. . . **Western Massachusetts Section** (*R. T. Bogan*) joined with the Western Massachusetts Engineering Society for a January tour of the Strathemore Paper mills at Woronoco. . . **South Texas Section** (*E. E. Ludwig*) in February combined a tour of the Newgulf mining facilities of Texas Gulf Sulphur Co. with a dinner meeting at which John McKetta discussed the benefits of national A.I.Ch.E. membership, and N. R. Amundson, Univ. of Minn., talked on New Mathematics in Chemical Engineering. . . Comprehensive talk on the design and application of jet ejectors and jet vacuum pumps was given by C. G. Blatchley, Schutte and Koerting Co., to the December meeting of the **Memphis Section** (*T. A. Feazel*).

NEW, Pyrometer Indicator

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Small Size Extremely small and compact, this null balance Portable Potentiometer Indicator weighs under four lbs. and measures only 4" x 5" x 6".

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Write for Bulletin 64-V.

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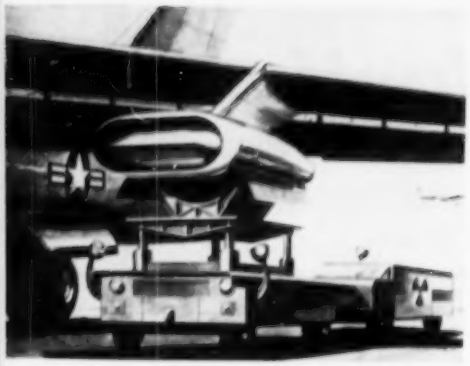


High temperature nuclear reactor exhaust gases power turbojet engine. GE made announcement (March 9) of success of Aircraft Nuclear Propulsion Dept. project. Artist's sketch shows possible installation method.

NUCLEAR CONGRESS

Above, press conference. Below, Nuclear Engrg. Div. board meeting.

HYDRAZINE BY TANKER—Stainless tank, similar to that used for HNO_3, holds first shipment of hydrazine by tank car.

W. K. Davis of AEC, vice-chmn. of Nuclear Div., A.I.Ch.E., welcomes Norwegian delegation to Congress.

Davis addressing Nuclear Div. dinner during Congress week.

Nuclear Div. chairman Herb Isbin (Univ. Minnesota) presiding at dinner prior to Davis' address.

At EJC all-Congress dinner, A.I.Ch.E. president Rushton.

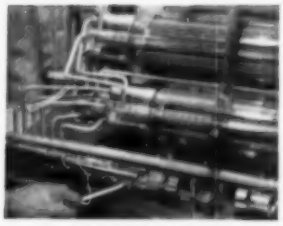
Below, at EJC all-Congress dinner, Admiral Foster (AEC) & A.I.Ch.E. past president Whitman (toastmaster).

Left to right: Pres. Rushton & Sam Friedman; Mr. Kirkpatrick; Mrs. Wickens & Prof. Brown (Labor). Left: Van Antwerpen & Kirkbride at 50th Anniv. Comm. meeting.

Left to right: W. A. Crichley, Diamond Alkali; R. L. Hershey, Du Pont; H. A. Hashberger, Monsanto; R. H. Gregory, Sloan School of Industrial Management, MIT. (Members of White Sulphur Symposium on "Computers in Chemical Company Control.")

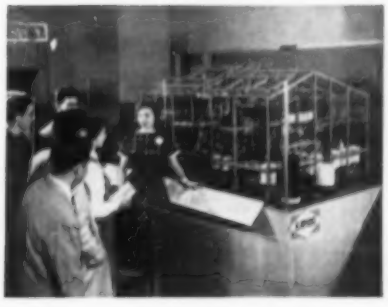
AT THE GREENBRIER

Left to right: D. H. Wade, R. K. Ramsey, E. R. Swandby, G. S. Nash, J. S. Bowen, J. E. Coffman, J. Grossman, C. D. Clancey, Mrs. E. L. Foerster, Dr. G. C. Gross, Mrs. G. C. Gross, E. L. Poling, Mrs. J. A. Davis, H. A. Leet, B. E. Dunaway, Mrs. R. K. Ramsey, E. L. Foerster, J. A. Davis, Dr. J. W. Eldridge, Mrs. W. T. White, Jr., Dr. C. E. Schwartz, L. P. Murray, W. B. Stone, Mrs. L. P. Murray, W. R. Horne, Mrs. W. R. Horne, Dr. O. L. Updike, W. T. White, Jr., C. E. Bruthaupt, W. R. Cathcart.



ATOMIC EXPOSITION

Clockwise: Pfaudler kettle & head; Seawolf exchanger model; Blaw-Knox reactor fuel processing model viewed by h. s. students; graphite; J. J. Martin at "console" operating Aerojet reactor.



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CANDIDATES FOR MEMBERSHIP IN A. I. Ch. E.

The following is a list of candidates for the designated grades of membership in A.I.Ch.E. recommended for election by the Committee on Admissions.

These names are listed in accordance with Article III, Section 8 of the Constitution of A.I.Ch.E.

Objections to the election of any of these candidates from Members and Associate Members will receive careful consideration if received before May 15, 1957, at the office of the Secretary, A.I.Ch.E., 25 West 45th Street, New York 36, N. Y.

Member

Ashton, Edwin C., *Jr., Downingtown, Pa.*
Bradt, L. D., *Saltville, Va.*
Brunsting, Elmer H., *Pryor, Okla.*
Burrell, D. L., *Richmond, Va.*
Coggan, L. B., *Madison, N. J.*
Doherty, Joseph D., *Huntington, W. Va.*
Ells, Frank J., *Haddon Heights, N. J.*
Feldman, Albert, *Baton Rouge, La.*
Finn, R. K., *Ithaca, N. Y.*
Floyd, Clyde M., *Baytown, Tex.*
Glass, John A., *Akron, Ohio*
Green, Stanley J., *Pittsburgh, Pa.*
Griffith, T. E., *Tulsa, Okla.*
Griffiith, William Porter, *Memphis, Tenn.*
Hartz, John J., *Akron, Ohio*
Knapp, Pete, *Jr., Tallmadge, Ohio*
Laursen, Fenn, *Penns Grove, N. J.*
McDowell, David L., *Lewisburg, Pa.*
McMinn, T. D., *Jr., Texas City, Tex.*
Nauman, E. F., *Marshall, Tex.*
Nelson, J. M., *Orange, Tex.*
Patterson, Leroy B., *Wilmington, Del.*
Pennell, John D., *Jr., Stamford, Conn.*
Pope, B. J., *Salt Lake City, Utah*
Reed, Earl R., *Midland, Mich.*
Savory, Leonard E., *Shreveport, La.*
Smith, Kenneth A., *Homewood, Ill.*
Staib, John H., *Plainfield, N. J.*
Street, Edward P., *Jr., West Point, Pa.*
Stubbs, Marshall, *Army Chemical Center, Md.*
Vander Ploeg, A. R., *Port Arthur, Tex.*
Vik, Olav R., *No. Claymont, Del.*
Wolsted, Howard L., *Danville, Ill.*

Associate Member

Barham, William L., *Baton Rouge, La.*
Beck, Earl W., *Midland, Mich.*
Berberian, Albert G., *Milton, Mass.*
Bermudez, G. L., *Toledo, Ohio*
Bitner, Leland R., *Houston, Tex.*
Blakemore, John W., *Wilmington, Del.*
Boley, Phillip C., *Topeka, Kan.*
Brevik, Dennis J., *Royal Oak, Mich.*
Briggs, Leland R., *Baton Rouge, La.*
Burris, Conrad T., *New York, N. Y.*
Capes, Louis G., *Great Kills, Staten Island, N. Y.*
Chapman, Dale E., *Lawrence, Kan.*
Ciepiela, Edmund John, *Preston, Ont., Can.*
Claes, Arthur L., *Detroit, Mich.*
Colosky, Dolph D., *Midland, Mich.*
Conde, Richard F., *Fort Belvoir, Va.*
Cooper, Harrison R., *Houston, Tex.*
Davis, Gregory E., *Channelview, Tex.*
Demirjian, Harry, *Detroit, Mich.*
Earhart, Harold William, *Baytown, Tex.*
Ferrari, John A., *Detroit, Mich.*
Fessler, H. B., *Jr., Port Isabel, Tex.*
Fitz, Richard A., *Richmond, Calif.*
Flemming, Edward D., *Detroit, Mich.*
Flockhart, Edwin A., *Verona, Pa.*
Ford, Robert C., *Columbus, Miss.*
Giles, Bruce D., *Union Springs, N. Y.*
Green, Kenneth J., *Bartlesville, Okla.*
Hall, Eldon L., *Wilmington, Del.*
Halper, Walter M., *Los Angeles, Calif.*
Henderson, Richard W., *Rahway, N. J.*
Hendrickson, Hubert E., *Longview, Wash.*
Hoff, Samuel L., *New York, N. Y.*
Holman, Joseph L., *Louisville, Ky.*
Honeychurch, Robert W., *Stamford, Conn.*
Horvath, Steven M., *Wyandotte, Mich.*
Jacob, R., *Paris, France*
Jenkins, Marie H., *Ridgecrest, Calif.*
Kemp, Ralph E., *Clayton, Ohio*
Key, Jesse A., *Midland, Mich.*
Lakomski, Peter E., *New York, N. Y.*
Leitinger, Joseph C., *Vienna, W. Va.*
Lengauer, Thomas E., *Detroit, Mich.*
Linskey, Elwood F., *Argo, Ill.*
Marks, L. T., *Jr., Wilmington, Del.*
Mattson, Robert J., *Penns Grove, N. J.*
Mayes, Warden, *Big Spring, Tex.*
McClune, Lloyd A., *Broomall, Pa.*
McGillivray, Richard J., *Chicago, Ill.*
McLane, Martin M., *Texas City, Tex.*
McNamee, Gerald P., *Detroit, Mich.*
Mollica, Richard J., *Jr., Detroit, Mich.*
Neils, Howard W., *Bismarck, N. D.*
Nussbaum, Edward M., *Freeport, Tex.*
O'Hare, Thomas E., *Fresh Meadows, N. Y.*
Pano, Benjamin V., *Boston, Mass.*
Philip, James B., *Morristown, N. J.*
Rohr, Franklin J., *Detroit, Mich.*
Sammond, John H., *Parlin, N. J.*

INSTITUTIONAL NEWS

A one week intensive short course in Statistics Methods for research workers in industry and the physical sciences will be held by The Institute of Statistics at North Carolina State College, Raleigh, N. C., the week beginning June 3. The course will be run in an elementary and an advanced session. Registration fee of $100 will be charged, course limited to 50. □

A conference on Automatic Control in the Petroleum and Chemical Industries will be held at the University of Oklahoma, Norman, Okla., April 29-30. □

Annual meeting of the Chemical Market Research Association will be held May 27-28 at the Hotel Plaza in New York City. Theme of the meeting is "Basic Forces for Change in the Chemical Industry." □

The New York State Society of Professional Engineers will be host to the 1957 Engineering Industries Exposition in conjunction with NYSPE's annual convention on May 16, 17 and 18 at the Statler Hotel in New York City. The Exposition, which integrates exhibits in all branches of engineering, will also be in the Statler. □

Special summer courses in Stress Analysis and Infra-red Spectroscopy will be offered by MIT running from June 17 through June 28. □

Northeast Region Spring Conference on Corrosion Control by Choice of Materials will be held at Syracuse Univ. and the Hotel Syracuse, Syracuse, N. Y., May 20, 21 and 22, 1957, under the auspices of the National Association of Corrosion Engineers, Central New York Section, and Syracuse Univ. □

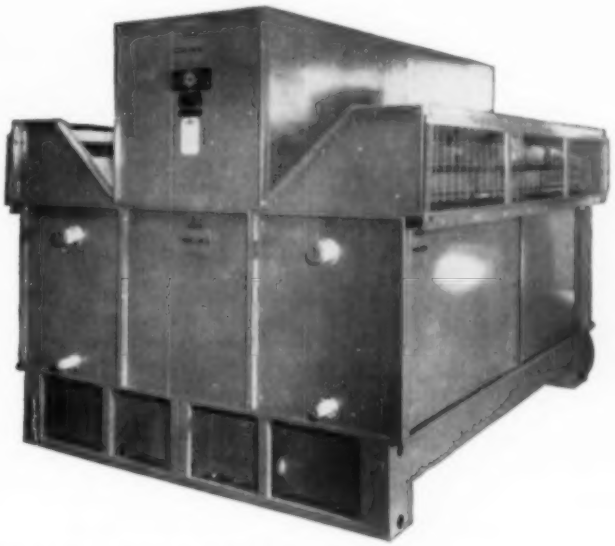
CANDIDATES

(Continued)

Sand, John J., *Buffalo, N. Y.*
Sausaman, C., *El Cerrito, Calif.*
Schafer, Robert J., *Farmington, Mich.*
Schneider, Robert C., *Gloucester City, N. J.*
Schulz, Arthur C., *Buffalo, N. Y.*
Seltzer, Allan D., *New York, N. Y.*
Shaughnessy, C. Patrick, *Royal Oak, Mich.*
Siegel, Harris T., *Rochester, N. Y.*
Silber, Alvin D., *New York, N. Y.*
Sumrall, George T., *Houston, Tex.*
White, Richard J., *Media, Pa.*
Williams, Carl L., *Rouses Point, N. Y.*
Woods, Jess Brooks, Jr., *Gary, Ind.*
Yunis, S., *Columbia, Mo.*
Zanowick, Richard L., *Oakmont, Pa.*
Zeman, John J., *Arlington, Mass.*

Affiliate

Clarke, Ewell A., *Baytown, Tex.*



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people

A. J. Broggini named president of Badger Manufacturing Co., Cambridge, Mass. At the same time, Badger announces the appointment of

Broggini

McCoy

C. Dana McCoy as international director. McCoy was previously international director and New York manager of Rust Engineering Co.

Westinghouse Electric Corp. appoints **Clarence Zener** as director of the Westinghouse Research Laboratories. Dr. Zener was formerly a professor in the Institute of Metals and the Department of Physics at the University of Chicago.

Newly-appointed manufacturing superintendent at the Marcus Hook plant of American Viscose Corp. is **Albert G. Ruff, Jr.**

Rogers

Julian A. Rogers is named head of the Manufacturing Department of W. R. Grace's high density polyethylene plant in Baton Rouge, La.

Honorary Membership in the American Institute of Chemists, New York Chapter, conferred on **Lawrence H. Flett,** consultant to National Aniline Division, Allied Chemical & Dye Corp.

Miller W. Swaney appointed coordinator of chemical and lube oil processes by Esso Research and Engineering. Swaney will be succeeded as director of the Products Research Division by **Neil V. Hakala.** New members of Esso's Design Engineering Division are **Harold N. Wells** and **Ernest E. Moore. Howard M. Siegel** and **Eric E. Van der Schraaf** have joined the Planning Engineering Division at Esso.

Pruiss

Carl E. Pruiss, formerly with Solvay Process Division, Allied Chemical & Dye, joins engineering staff of R. B. MacMullin Associates, Niagara Falls, N. Y.

Ozalid Division of General Aniline & Film, Johnson City, N. Y., names **Marshall R. Modery** as chemical process supervisor.

New supervisor of research for Petro-Tex Chemical Corp., Houston, Texas, is **Carroll Karkalits.** Karkalits comes to Petro-Tex from Food Machinery and Chemicals Corp.

Iliff

Appointment of **James E. Iliff** as vice-president and general manager of Davidson-Kennedy Associates Co. is announced. Iliff will direct the Chicago office of the engineer-contractor firm.

Irving D. Canton appointed assistant manager of the International Research Department at Armour Research Foundation of Illinois Institute of Technology, Chicago.

S. Crawford Bonow is elected vice-president of Stein, Hall & Co. Bonow has been with Stein Hall since 1946.

Bonow

(Continued on page 128)

NEW DEVELOPMENTS from A.I.Ch.E.

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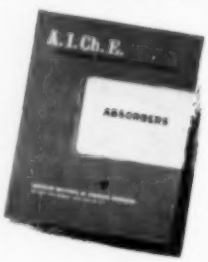

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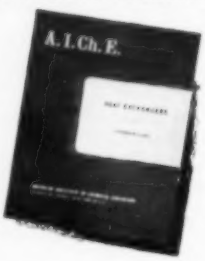

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A. I. Ch. E.

50 ANNIVERSARY

CONTEST

What Slogan, What Symbol Characterize Chemical Engineers?

$250 FOR THE WINNING SLOGAN / **$250** FOR THE WINNING SYMBOL

In 1958, A.I.Ch.E. will observe its 50th Anniversary. High point of the year's celebration will be a week-long meeting in Philadelphia June 22-27. Plans are already underway which will make the Anniversary outstanding. Special volumes are now in preparation on chemical engineering, noted speakers and authors are already preparing for an historic event of great importance to chemical engineers. A.I.Ch.E. would like a slogan and a symbol to use all year as an identification of this great profession. The contest is open — if your wife is a demon at design, and if you are wise with words, make it a team project. **But a separate contest is being held for both SLOGAN AND SYMBOL.** Don't worry too much about the finished drawing — professional draftsmen and artists will reproduce the drawings submitted. Entries will be judged by the 50th Anniversary Committee, composed of past presidents of A.I.Ch.E. For further information, see page III of this issue.

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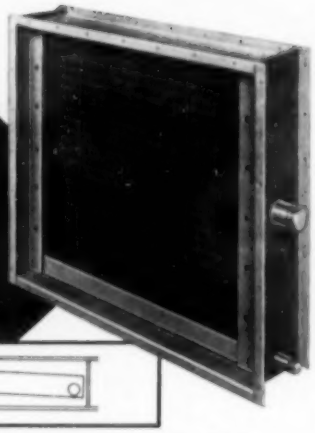

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REMPE COMPANY

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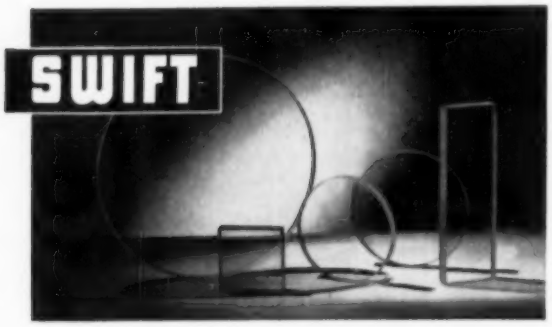


a fast, convenient source for

PYREX SIGHT GLASSES

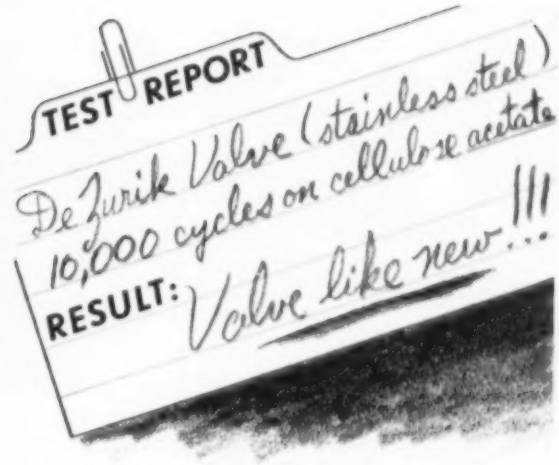
We can supply perfectly true circles, precision-ground from heat-resistant polished plate glass. Used by chemical companies from coast to coast —resist clouding, pitting, chemicals (except HF and strong hot caustic solutions).

Squares, rectangles or odd shapes in 8 thicknesses (⅛" to 1"), sizes up to 24" x 60", also available for immediate shipment. Write, wire or phone for bulletin or quotation.

SWIFT *Glass Division*

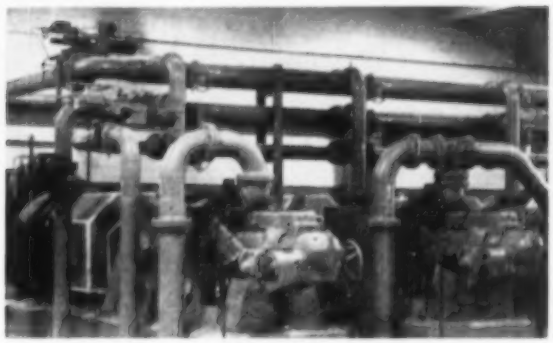
SWIFT LUBRICATOR COMPANY, INC.

8 Glass St., Elmira, N.Y.



A leading chemical firm recently made a test involving a 4" DeZurik Stainless Steel Valve on a line carrying cellulose acetate. *After 10,000 cycles,* the DeZurik Valve was removed and dismantled. The engineer in charge reported there was no galling or pitting . . . no deterioration of any kind! "In fact," he said, "if I hadn't seen it taken out myself, I'd say it was a new valve!"

DeZurik Valves consistently rate test reports like this. Their easy, non-lubricated operation guarantees maintenance-free installations. They open wide with a quarter-turn, close dead-tight despite solids in the flow.



The full line of DeZurik Valves includes models in a broad range of materials (also with TEFLON* faced plugs). They can be furnished to operate manually, pneumatically, hydraulically (with or without positioner) and electrically. Get the complete story on DeZurik Easy-Operating, Non-Lubricated Plug Valves. Representatives in all principal cities. Or write Dept. CEP-4.

DeZURIK CORPORATION

SARTELL, MINNESOTA

* Reg. TM—DuPont

ACE has The POLYETHYLENE WARE You Want

WM HH —BOTTLES, Wide Mouth

HH —FLASKS, FILTERING

QUICK CONNECTOR

STOPPERS

Write Dep't. PW— G for Brochure Showing the Wide Range of Ace POLYETHYLENE WARE

Also in Stock for Immediate Shipment at our Midwestern Division 639-41 South Hancock St., Louisville, Ky

ACE GLASS INCORPORATED
VINELAND ♠ NEW JERSEY
639-41 SOUTH HANCOCK ST.
LOUISVILLE, KY.
Glassware Specialists to Industry and Research

people

Forrester

Jay H. Forrester, president of the Amoco Chemicals Corp., Chicago, appointed Illinois state chairman for Chemical Progress Week. Appointment was made by the Manufacturing Chemists Association.

Dorr-Oliver, Inc., announces the retirement of **George M. Darby,** director of the Westport Mill, Dorr-Oliver Laboratories, at Westport, Conn. Darby has been associated with the company's experimental and development program for the past 37 years.

Davis R. Dewey, II, elected president of Baird-Atomic, Inc. Dewey was formerly vice-president of High Voltage Engineering Corp., Burlington, Mass.

Vaughn

James L. Vaughan has joined the Dewey and Almy Chemical Co. Division of W. R. Grace & Co. as assistant research director in charge of process design and development.

Alfred R. Smith is appointed by Scientific Design Co., N. Y., as assistant to the vice-president, new project development. Smith was formerly a director of Sharples Chemical and Industrial Ltd., Nassau, Bahamas.

Sommers

Howard A. Sommers, formerly chief engineer of Food Machinery and Chemical Corp., Chemical Division, N. Y., is now consulting engineer of Air Products, Inc., Allentown, Pa.

New member of the Development Department at the South Charleston, W. Va., plant of Carbide and Carbon Chemicals Co. is **R. J. Hanna.**

The new New York City office of Chemineer, Inc., manufacturers of fluid mixing equipment, will be managed by **John G. Papailias.**

Dean E. Humphrey joins staff of Godfrey L. Cabot's Research and Development Laboratories at Cambridge, Mass.

Don Sutherland has joined the Atomic Energy Division of Phillips Petroleum Co. as operations coordination engineer.

Lauren B. Hitchcock, former New York consultant and recently president of the Air Pollution Foundation, opens consulting offices in Los Angeles.

Haines

Walter Kidde Engineers Southwest, Inc., announces appointment of **Harry Haines** as petrochemical contract engineer.

Managerial changes at Solvay Process Division, Allied Chemical & Dye, include promotion of **Frederick Nill** to assistant to the director of development, **James E. House** to assistant to the director of operations, **William J. Bobek** to manager, and **Paul B. Cornell** to assistant manager.

Williams

Appointment of **Ralph D. Williams** as vice-president and **William R. Whitener** as sales manager has been announced by Lake Asbestos of Quebec Ltd., a subsidiary of American Smelting and Refining Co.

Bion D. Barger, Jr., joins staff of Whiting Research Laboratories of the Standard Oil Co. (Indiana).

Diamond Alkali Company announces promotion of **D. R. Pulver** to position of process engineer in the Chlorinated Products Division.

DuPont announces the retirement of **Harold L. Maxwell,** special assistant to management in the Engineering Service Division, after a 27-year career, and of **Walter Dannenbaum,** vice-president and member of the executive committee, after 43 years of service. Also at DuPont, **Robert E. McDonald** becomes technical superintendent of the company's nylon plant at Seaford, Del. McDonald was formerly research manager of DuPont's Dacron Research Laboratory.

Grosvenor

New director of research and development of American Sugar Refining Co. is **William M. Grosvenor, Jr.** Grosvenor has been doing consulting work for American Sugar for the past year.

(Continued on page 129)

MISCO

Specialists IN NICKEL-BEARING ALLOY FABRICATION

Heat and Corrosion Equipment

Processing Equipment

Specialized CORROSION RESISTING ALLOY

- Design
- Development
- Fabrication

MISCO Engineered

TANKS • PIPING

PRESSURE VESSELS

BUBBLE TOWERS

SPECIAL EQUIPMENT

Specify MISCO DESIGN and FABRICATION

IT COSTS NO MORE!

MISCO FABRICATORS, INC.

Designers, Builders, Fabricators of Heat Resisting Alloy and Stainless Steel Equipment

2420 Wills Ave. • Marysville, Mich.

Telephone: YUKON 5-6191

people

Commercial Solvents Corp. names **Richard M. McGhee** as chief engineer and **Homer E. Kieweg** as manager of the Technical Development

McGhee

Kieweg

Department. McGhee has been associated with Commercial Solvents for 14 years and Kieweg for more than 25 years.

American Potash & Chemical Corp. promotes **Joseph Adinoff** to senior development engineer. Mr. Adinoff will be headquartered at the company's main office in Los Angeles.

Joseph A. McGroarty named to newly-created post of industrial accounts manager in the sales department, Chemical Division of Merck & Co., Inc., Rahway, N. J.

the chemical engineer in MARKETING

H. E. P. Barta named to post of manager of Product Engineering Sales Division for the Pfaudler Co., Rochester, N. Y.

Barta

Two promotions are announced by the sales department of Hooker Electrochemical. **William L. Gillespie** becomes manager, sales administration, and **John T. Walmsley** will be manager, Chicago district sales.

Manager at the new Atlanta, Ga., office of the Babcock & Wilcox Company's Tubular Products Division will be **William Lehr.**

Charles R. Schroth will assume post of sales manager for the Acheson Dispersed Pigments Co.

Thomas R. Drinkwater has been made assistant to the manager of Alcohol and Chemical Sales for U. S. Industrial Chemicals Co., Division of National Distillers Products Corp.

(Continued on page 138)

DOW CORNING SILICONE DEFOAMER!"

*The most effective defoamers ever developed, **just 1 teaspoonful kills foam in—***

12,500 gallons sodium bromide solution

5,000 gallons vat dye solution

2,500 gallons starch sizing

1,250 gallons black liquor

You can reduce processing time, increase output from present equipment and lower production costs with a Dow Corning Silicone Defoamer.

Try new ANTIFOAM B

Stops foaming of even the most violent and stubborn foamers quickly and economically with a minimum of fuss. Many chemical processing plants are standardizing on this new, more stable and easier-to-use silicone defoamer. Test Antifoam B in your plant and see how it saves time, space and MONEY!

For FREE SAMPLE of Antifoam B and full information, address

Dept. 3016

first in silicones

DOW CORNING CORPORATION

MIDLAND, MICHIGAN

CLASSIFIED SECTION

Address Replies to Box Number Care of CHEMICAL ENGINEERING PROGRESS

SITUATIONS OPEN

AMERICAN OIL

AMOCO

Professional Career Opportunities

Major oil company with plants located in Texas, Virginia, Arkansas, and Louisiana. Major Research and Development activities located in Texas City, Texas. Considerable expansion underway.

CHEMICAL ENGINEERS

required for process design, process development and technical service to refining and chemicals manufacture. BS, MS, PhD, 0-10 yrs. experience.

Amoco is the nation's only unleaded premium gasoline. American Oil offers a unique challenge in an industry long known for top opportunities to competent chemical engineers.

♦

Send résumé to
Administrative Director
Research & Development Dept.
AMERICAN OIL COMPANY
Texas City, Texas

DESIGNERS

WHAT major organization offers continual original work assignments?

For the answer, turn to page 40.

ENGINEERS

Process

Assignments in our Process Engineering Department for engineers with three to six years experience range from integrated refineries and chemical plants through all types of individual process units. The work includes heat and material balance, and computations for unit operations such as fractionation and heat-transfer. Send a summary of your experience and interests to F B Stratford, Head of Personnel, C F BRAUN & CO, Alhambra, California.

ESSO RESEARCH LABORATORIES

Participant in Research and Development Projects of Standard Oil Company (New Jersey)

BS, MS and **PhD CHEMICAL ENGINEERS** needed in expanding petrochemical and fuels research and development program. Excellent facilities include wide range of pilot units from bench-scale to semi-commercial size, extensive shop facilities and high-speed computers for theoretical and process calculations.

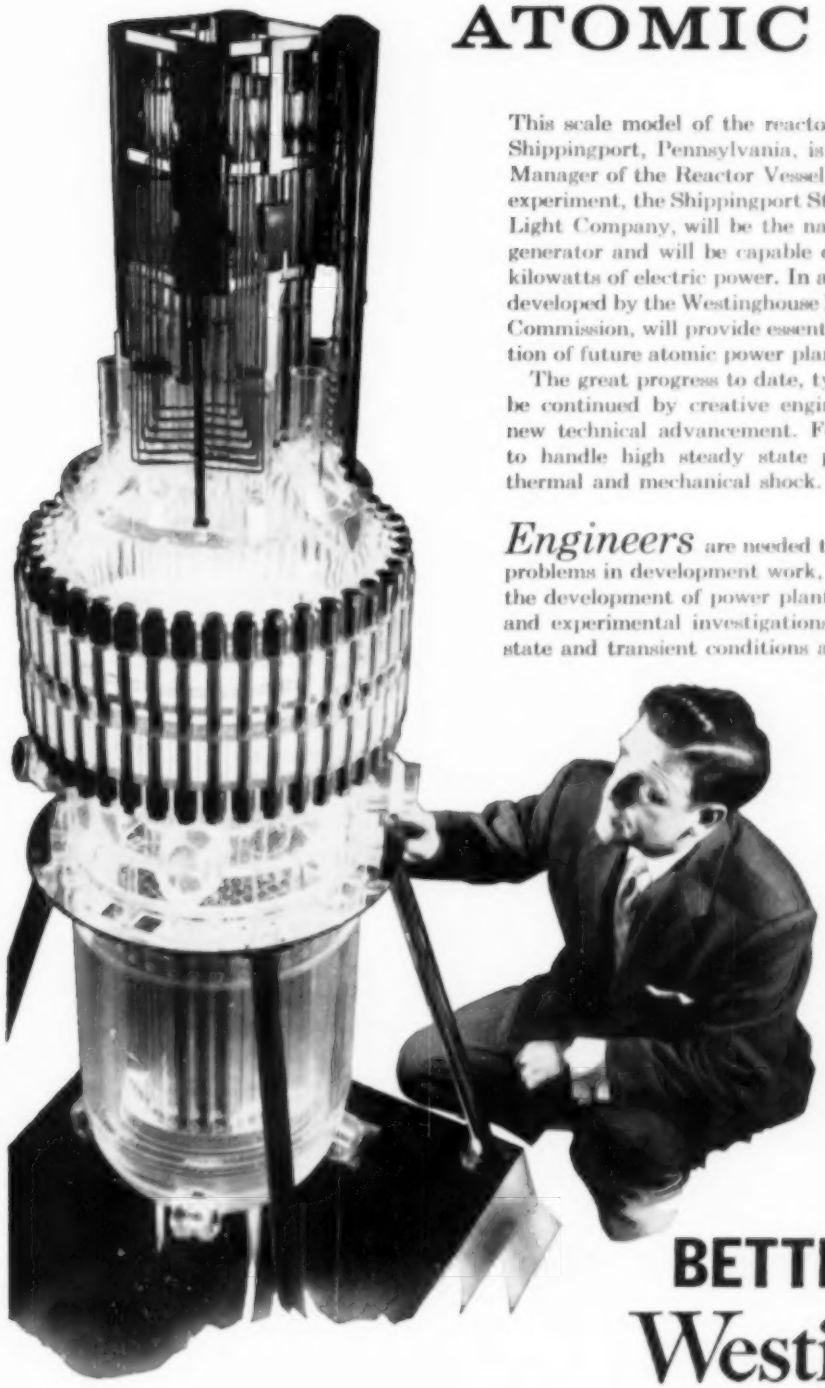
Location—Baton Rouge, Louisiana, a progressive community of 150,000, state capitol, home of Louisiana State University and chemical center of the South.

Give full details of education, experience, date available and references. All inquiries will be considered promptly and held confidential.

Esso Research Laboratories, Department A
Esso Standard Oil Company
P. O. Box 551
Baton Rouge, Louisiana

creative opportunities in

ATOMIC POWER



This scale model of the reactor for the atomic power station at Shippingport, Pennsylvania, is being checked by P. A. Halpine, Manager of the Reactor Vessel Design for this project. No small experiment, the Shippingport Station, to be operated by Duquesne Light Company, will be the nation's first full-scale atomic power generator and will be capable of producing a minimum of 60,000 kilowatts of electric power. In addition, this plant, which is being developed by the Westinghouse Bettis Plant for the Atomic Energy Commission, will provide essential data for the design and operation of future atomic power plants.

The great progress to date, typified by the USS *Nautilus*, must be continued by creative engineers who enjoy the challenge of new technical advancement. For instance, ways must be found to handle high steady state pressures accompanied by severe thermal and mechanical shock.

Engineers are needed to solve unusual thermal and stress problems in development work, particularly in reactor design and the development of power plant auxiliaries. Extensive theoretical and experimental investigations into heat transfer under steady state and transient conditions are necessary to determine reactor design parameters. Atomic experience is not a prerequisite.

Bettis Plant, located in Pittsburgh's South Hills, is adjacent to comfortable suburban living as well as convenient to one of the nation's most progressive cities where educational opportunities for advanced study are exceptional.

If you are interested in working in the expanding field of atomic power, write for the brochure, "Tomorrow's Opportunity Today." Address Mr. A. M. Johnston, Westinghouse Bettis Plant, Dept. A-129, P.O. Box 1468, Pittsburgh 30, Pa.

BETTIS PLANT

Westinghouse

P.O. BOX 1468, PITTSBURGH 30, PENNSYLVANIA

ORO ANNOUNCES CHALLENGING OPENINGS IN

OPERATIONS RESEARCH

Operations research is a fast growing and practical science attracting some of the best brains in the country. Its future is unlimited. If you want to join a group of pioneers in this new and exciting field, we invite you to investigate the openings available on our staff. Men required must be capable of thinking creatively, must be able to work on their own *and* within a group, and must be keenly interested in finding answers to practical problems.

ON OUR PART WE OFFER:

1. A record of experience in operations research, out-distanced by perhaps no other organization.

2. A scrupulously maintained professional approach and atmosphere.

3. The team approach to problem solving. On each team are representatives of varied disciplines—sometimes three, occasionally as many as a dozen.

4. Fully equipped digital and analog computing facilities.

5. ORO occupies several buildings in Chevy Chase, Maryland, one of America's most attractive suburbs. Pleasant homes and apartments in all price ranges are available for rental or purchase. Schools are excellent. Downtown Washington, D. C., with its many cultural and recreational advantages is but a 20-minute drive.

6. Favorably competitive salaries and benefits, extensive educational programs, unexcelled leave policy.

FOR DETAILED INFORMATION, WRITE:
Dr. L. F. Hanson

OPERATIONS RESEARCH OFFICE
ORO The Johns Hopkins University
7100 CONNECTICUT AVENUE
CHEVY CHASE 15, MARYLAND

BECHTEL

NEW YORK
OR
SAN FRANCISCO

Offers immediate long range opportunities for

ENGINEERS

Chemical—Mechanical

Process or project experience in refinery, petrochemical or chemical fields.

Liberal relocation allowances for you and your family.

Send resume to
Manager of Employment & Placement
Industrial Relations Division

BECHTEL
Engineers and World-Wide Builders for Industry
220 Bush Street
SAN FRANCISCO 4, CALIF.

Recruiting Offices in New York, Houston, San Francisco and Los Angeles

ENGINEERS

Heat
Exchangers
Pressure Vessels

Men with refinery or chemical plant experience who are familiar with process design and estimating of heat exchangers and fractionation columns. Responsible positions with an outstanding manufacturer. Good salaries. Profit-sharing retirement plan. Allowance for moving to Southern California. Send a summary of your experience and interests to F B Stratford, Head of Personnel, C F BRAUN & CO, Alhambra, California.

DO YOU HAVE A NOSE FOR O. R.?

You wouldn't believe that a submarine hunt could develop into a profession, but it did. Nor that the "thinking" of a gambler would end up as a stalwart tool of this same profession, but it did. The profession is Operations Research.

In our organization we are taking these quaint items in stride as we use O. R. Cautiously at first, then more enthusiastically, we have found that the ideas really work. We have found that the use of electronic computers is helping us design plants much faster. In fact, we feel justified in hailing the use of the electronic brain as a major break-through in engineering work. We need the help of mathematicians and mathematically inclined chemical, mechanical and electrical engineers in this work.

We have found that math can be both "long-hair" and practical. Linear programming, the Monte Carlo technique, statistics, computing, servo-mechanism theory and queueing theory are helping to solve hitherto insolvable problems. In fact, we feel so good about this whole business that we have recently set up an Operations Research Section to do professional snooping.

We need men to fill it:

—who look forward to wrestling with new ideas
—who don't mind reaching way back into the rarified realms of modern mathematics for the tools needed to solve problems
—who won't accept the traditional way of doing things as final
—who have the patience to collect data, puzzle out their meanings, spin mathematical hypotheses and test them out on computers
—in short, technical men who welcome adventure—physical and mental.

If you are interested in this kind of work, write us. We represent a large, integrated company in the oil industry. Here is opportunity on the ground floor in a new exciting and rapidly growing profession. Please address your letter to Box 3-4. Care of CHEMICAL ENGINEERING PROGRESS.

CHEMICAL ENGINEERS

BS, MS or PhD

- **FOR PROCESS ENGINEERING**

  Process engineer with specialized background in unit operations, especially distillation and extraction. To function with high level staff in consulting capacity to plant and divisional management on process improvements and design.

- **FOR DEVELOPMENT ENGINEERING**

  Graduate engineers with up to 10 years' experience in process development, production or process engineering. Duties will involve working with supervisory staff on development problems, including pilot plant operation.

Celanese's new textile headquarters in lovely Charlotte, North Carolina can provide the very best facilities for the full utilization of engineering talent. Personal and professional progress is encouraged . . . and advancement opportunities are available due to the planned expansion program.

If your background qualifies you for one of these newly created positions, send a resume to L. H. Hitchens. Please include your initial salary requirements.

Celanese CORPORATION OF AMERICA • P. O. Box #1414, Charlotte, North Carolina

ENGINEERS

Process

Assignments in our Process Engineering Department for engineers with eight or more years of experience cover process design, selection of processing steps, and economic evaluation of processes. Other work may include market analysis, industrial surveys, and technical assistance to sales. Send a summary of your experience and interests to F B Stratford, Head of Personnel, C F BRAUN & CO, Alhambra, California.

CHEMICAL ENGINEERS

American Viscose Corporation, a chemical-process industry, has some **permanent** positions open now for **chemical engineers.** To qualify you need a B.S. or M.S. degree from a recognized institution, and, preferably, 3-5 years of experience in process development, product-improvement studies, or chemical engineering 'trouble-shooting' for manufacturing.

The location is in suburban Philadelphia (Marcus Hook) at the **Research and Development Division,** or at one of our seven plants in Pennsylvania, West Virginia, and Virginia.

AVISCO

These openings are technically challenging and offer good advancement opportunities. Interested candidates are invited to submit résumés of personal data, educational history, and work experience to:

Personnel Recruitment Department

AMERICAN VISCOSE CORPORATION
1617 Pennsylvania Boulevard
Philadelphia 3, Pennsylvania

Heat Transfer Engineer

Young man 28 to 40 years capable of design, rating and sales of heat exchangers. Established fabricator located in S.W. City of 300,000.

Reply stating full particulars as to education, employment background and qualifications.

Salary commensurate with experience and ability. All replies kept confidential. Reply to box No. 1-4.

SEE CHEMSTRAND'S AD on Page 55 of THIS MAGAZINE

Positions available for

ENGINEERS

(Chemical, Mechanical, Metallurgical, Textile, Industrial, Instrument and Civil) and

CHEMISTS

(Organic, Physical Analytical—Instrumental and Wet Method, Textile Chemists.)

Write to Technical Personnel Department

THE CHEMSTRAND CORPORATION
Decatur, Alabama

Chemical Engineering Faculty member needed. Rank and salary dependent upon qualifications. Send résumé and recent photo to: Chairman, Chemical Engineering and Chemistry Departments, Fenn College, Cleveland 15, Ohio.

PROJECT ENGINEER—one or two years' experience. Design, layout, installation of fine organic chemical processes. Medium size plant, greater New York City area. Submit resume to Box 2-4.

TRAINEES FOR PROCESS EQUIPMENT SALES

As part of our expansion program, we have openings for one or more Chemical Engineers with a few years process experience who desire to make a career in sales. Training will involve handling sales correspondence, working in laboratory and pilot plant, starting up equipment in customers' plants and performing service work. At end of training period, man selected will have opportunity for outside sales work on an exclusive territory basis.

Wonderful opportunity for qualified engineers to increase their earning in proportion to their ability and effort.

Filtration Engineers, Inc.
155 Oraton St. Newark 4, N. J.

ENGINEER

Industrial Ventilation

Prefer chemical or mechanical engineer to design and make customer contacts in chemical fume removal systems. Permanent position with expanding company. Many benefits. Salary open.

HEIL PROCESS EQUIPMENT CORP.
12901 Elmwood Ave.
Cleveland 11, Ohio

DU PONT NOW OFFERS

SIX CAREER POSITIONS OF CHALLENGE AND RESPONSIBILITY FOR SPECIALIZED CHEMICAL ENGINEERS.

The Engineering Service Division of du Pont's Engineering Department provides consulting service and technical assistance to production, maintenance, design, research, and construction groups within the company. The Division's objectives are to assist other company units in improving plant efficiency and product quality, in reducing investment and operating costs, and in increasing capacity.

Six openings are immediately available for experienced graduate engineers to provide consulting service to operating plants in the following specialized chemical engineering fields:

WATER ENGINEER

The desirable background will include extensive experience in water procurement and treatment for industrial plants. Knowledge of water treatment plant operation through practical experience is important. The successful applicant will provide engineering advice to those designing, constructing and operating company plants on problems involved in the procurement and treatment of industrial water supplies.

PLASTICS ENGINEER

BS engineering or chemistry, minimum. 5-10 years experience in plastics engineering for process equipment and auxiliary services. Duties include consulting services covering development, evaluation, selection, specification and fabrication of plastics for chemical process equipment and auxiliaries; investigations of failures and recommendations of remedial measures.

PETROCHEMICAL ENGINEER

Successful applicant will analyze existing and proposed chemical processes for utilization of petroleum processing equipment and methods for obtaining greater yield and lower equipment investment, particularly with respect to hydrocarbon processes. Typical operations to be evaluated include solid fluidization, absorption, reforming, and catalysis. This requires broad familiarity with equipment such as hypersorbers, distillation columns, cracking furnaces, low temperature refrigeration systems, and compressors. Other duties include trouble-shooting and economic evaluation of alternative processes and equipment.

AIR CONDITIONING ENGINEER

BS in ME or equivalent minimum. At least 5 years' experience in analysis, design and development of industrial and comfort air conditioning and ventilating systems, particularly in equipment selection and performance, controls, practical layout and economics. Duties include consulting for Engineering and Plant Operations groups, and liaison with Company and outside personnel and organizations. Travel to plant and other locations required. Engineer should be articulate in speech and writing. Must be able to function with minimum supervision, to accept responsibility and to show mature initiative. Personal traits should fit man for dealing with people, and for developing to position of prominence in field.

PUMPS & FLUIDS

Desired qualifications will include extensive engineering knowledge of and familiarity with equipment used in the fluid mechanics field. Development, research, design, maintenance, or teaching experience with pumps, compressors, jets, and seals is desirable. Responsibilities of the position will involve selection of equipment, trouble-shooting, and consultation of fluid flow and mechanical design aspects of piping, pumps, jets, compressors, and seals. Duties include evaluation of available equipment and recommendations for equipment modification for special applications.

INSTRUMENTAL MEASUREMENT ENGINEER

Graduate engineer experienced in research, application, consulting or development of techniques for process variable measurement. Duties will include trouble shooting, consulting and technical assistance in application of IR and UV spectroscopy to automatic analysis of chemical process fluids, and instrument application in viscosity, temperature, pressure, flow and other process variable measurements.

PHILADELPHIA INTERVIEWS	SAN FRANCISCO INTERVIEWS
Sun-Mon-Tues-Wed	Tues-Wed-Thurs-Fri
April 28-29-30; May 1	June 11-12-13-14
For an appointment, please call	For an appointment, please call
Mr. K. S. Marlin, Jr.	Mr. K. S. Marlin, Jr.
WAlnut 2-8600	EXbrook 2-7755

DU PONT
REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING
...THROUGH CHEMISTRY

Or you may send complete resume, including details of education and experience to:
Mr. K. S. Marlin, Jr., Engineering Department
E. I. du Pont de Nemours & Co. Inc.
Wilmington 98, Delaware

ESSO EXPANSION NOW REQUIRES

SCIENTISTS AND ENGINEERS—for Operations Research projects throughout the Jersey Standard interests. These involve the study of terminal operations, transportation, and inventory control problems. Such studies typically mean one or more field trips to collect basic data and to define the problem; analysis of the data to develop "mathematical models" of the problem; close work with the client to incorporate the results of these studies, and finally, follow up on the results.

Give full details of education, experience, desired salary, availability date and references. All inquiries will be considered promptly and held confidential.

ESSO RESEARCH AND ENGINEERING COMPANY

(Chief Technical Subsidiary—Standard Oil Company (N.J.))

Esso Research Center
Employee Relations-C

P. O. Box 51 Linden, N. J.

ENGINEERS

Chemical
Mechanical
Petroleum

Assignments in our Chemical Engineering Department cover application of processes to a wide variety of industrial plants, complete integrated refineries and chemical processing centers. The work includes coordinating of chemical engineering, selection and design of process equipment and startup of completed plants. Send a summary of your experience and interests to F B Stratford, Head of Personnel, C F BRAUN & CO, Alhambra, California.

CHEMISTS, CERAMIC ENGINEERS, or CHEMICAL ENGINEERS to develop inorganic high-temperature electrical insulating materials

Westinghouse is actively engaged in research and development in the field of high-temperature stable inorganic electrical insulating materials capable of operation at more than 600°C. Additional openings exist for men with experience or interest in ceramics, ceramic cements, synthetic mica and asbestos, and inorganic polymers, chelates, etc.

Applicants should be graduate chemists or engineers preferably at the Ph.D. level, or equivalent in training and experience.

Excellent employee benefits—hospitalization plan, medical insurance, life insurance, retirement benefits, tuition reimbursement plan for advanced studies.

Challenging problems are offered in a professional atmosphere—location, suburban Pittsburgh, Pennsylvania.

Address inquiries to:

WESTINGHOUSE ELECTRIC CORPORATION
Materials Engineering Department
B. Stuart, Industrial Relations Supervisor
East Pittsburgh, Pennsylvania

PROCESS ENGINEERS

- Design
- Instrumentation
- Development

(Methods & Data)

●

CAREER OPPORTUNITIES IN

SOUTHERN CALIFORNIA

for men with experience in these fields for petroleum, petro-chemical, or chemical plants.

●

OFFERING MAXIMUM OPPORTUNITIES FOR:

Utilization & recognition of individual initiative & ability.

Broad responsibilities rather than narrow specialization.

Experience with a wide range of processes.

●

Liberal salary ranges, profit sharing, top benefits, & ideal working conditions.

Submit resume of training, experience, and work references to:

The FLUOR CORPORATION, LTD.

ENGINEERS—CONSTRUCTORS

2500 S. Atlantic Blvd.
Los Angeles 22, Calif.

SITUATIONS WANTED

A.I.Ch.E. Members

CHEMICAL ENGINEER—sixteen years' excellent experience: chemical, petro-chemical pilot plant work and responsible full-scale process design and start-up. Desire senior process engineering and/or development position with good potential. Salary $10,600 minimum. Box 5-4.

CHEMICAL ENGINEER—experience seven years' development (acids), design and data analysis. Experience with high temperature-high velocity compressible gases, instrumentation. B.Ch.E. degree, graduate credits. Salary desired $800 per month. Prefer New York City area. Box 6-4.

PROCESS-PROJECT ENGINEER—B.S.Ch.E. 1948. Nine years' design and operations, including six years' with major contractor. Experience includes gasoline and chemical plant process design, engineering, and start-up. South or Southwest preferred. Box 7-4.

CHEMIST-ENGINEER-SENIOR TECHNOLOGIST—B.S. Fifteen years' petroleum processing research. Two years' refinery technology. Publications. Patents. Especially strong background distillation. In responsible charge last twelve years. Desire challenging and responsible position. Gulf Coast. Box 8-4.

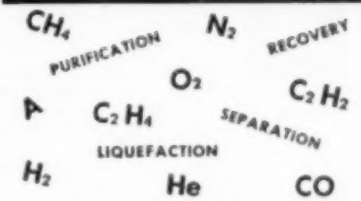
CHEMICAL ENGINEER—Ph.D. 31. Family. Eight years' experience engineering research, pilot plant development, process improvements, teaching. Publications, honoraries. Desire responsible position in research or development. Eastern, northeastern location. Minimum salary $10,000. Box 9-4.

CHEMICAL ENGINEER—Ph.D., age 37. Four years' industrial experience; ten years, teaching, research and consulting. Now professor at accredited school. Desire industrial position with responsibility. Box 10-4.

(Continued on page 138)

CHEMICAL & MECHANICAL ENGINEERS

are offered opportunity to advance professionally in diversified growth company



LOW TEMPERATURE PROCESSING

The Company is the leader in the engineering, design, manufacture and construction of plants and systems for the separation of gases such as Oxygen, Nitrogen, Carbon Monoxide, Hydrogen and other low boiling building blocks of the chemical industry. We must expand the entire organization to meet the increasing demands of the steel, metallurgical and chemical industries, and for national defense.

Selected Assignments

- **PROCESS DESIGN ENGINEERS**
- **RESEARCH & DEVELOPMENT ENGINEERS**
- **PROJECT ENGINEERS**
- **ESTIMATING & ECONOMIC EVALUATION ENGINEERS**
- **MECHANICAL ENGINEERS**
- **DESIGN ENGINEERS**
- **CONSTRUCTION ENGINEERS**
- **FIELD OPERATIONS MANAGER**
- **OPERATING SUPERINTENDENT**
- **MANUFACTURING & PROCESS ENGINEER**
- **SALES ENGINEERS**

AIR PRODUCTS, INC., situated in Eastern Pennsylvania at the foothills of the lovely Pocono Mountains, with ready access to three fine universities as well as other cultural and recreational facilities, offers you . . .

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Advertisements in the Classified Section are payable in advance at 20¢ a word, with a minimum of four lines accepted. Box number counts as two words. Advertisements average about six words a line. Members of the American Institute of Chemical Engineers in good standing are allowed one six-line Situation Wanted insertion (about 36 words) free of charge a year. Members may enter more than one insertion at half rates. Prospective employers and employees in using the Classified Section agree that all communications will be acknowledged; the service is made available on that condition. Answers to advertisements should be addressed to the box number, Classified Section, Chemical Engineering Progress, 25 West 45th Street, New York 36, N. Y. Telephone COlumbus 5-7330. Advertisements for this section should be in the editorial offices the 15th of the month preceding publication.

(Continued from page 137)

CHEMICAL ENGINEER — M.S.—obtaining M.B.A. Project leader with four years' diversified experience with major chemical company. Process development, reports, cost estimates — monomers, polymers, organics, latexes. Good organizer. Honor societies. Desire position with future within 50 miles of New York City. Box 11-4.

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the chemical engineer in MARKETING

Mack

Baker Perkins, Inc., Saginaw, Mich., announces that **Kenneth A. Mack,** sales manager of their Chemical Machinery Division, has been appointed a director of the corporation. Mack joined Baker Perkins in 1937.

Du Pont appoints **W. Samuel Carpenter, 3rd,** as director of sales of their Petroleum Chemicals Division.

New director of advertising for Allied Chemical & Dye will be **Michael P. Ryan.** Ryan comes to Allied from the Gardner Advertising Agency, St. Louis, where he was a vice-president.

O. R. Matzner joins sales engineering staff of the Girdler Company's Catalyst Department.

William R. Blackstock appointed market analyst in the Commercial Development Department of Pittsburgh Coke & Chemical Co. Blackstock has been with Pittsburgh Coke & Chemical since 1952.

Kenneth L. VanderVoort becomes Chicago district sales manager for the Jefferson Chemical Co. At the same time, **R. J. Robinson** has been named resident salesman at the newly-established Cleveland sales office of the company.

Commercial Solvents Corp. appoints **James V. O'Leary** as general sales manager.

Charles A. Wood named sales manager, East Central area, for Northeastern district of the Plant Food Division of Olin Mathieson Chemical Corp.

Necrology

R. W. Albright, 62, vice-president and general manager of Distillation Products Industries, Rochester, N. Y.

O. L. Polk, 60, assistant project engineer, Curtiss Wright Corp.

R. W. Brown, 65, retired, formerly with the Aluminum Co. of America.

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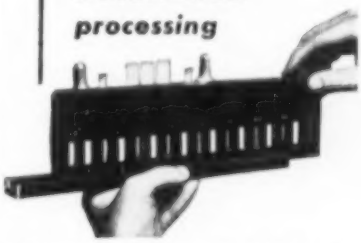

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news and notes of A.I.Ch.E.

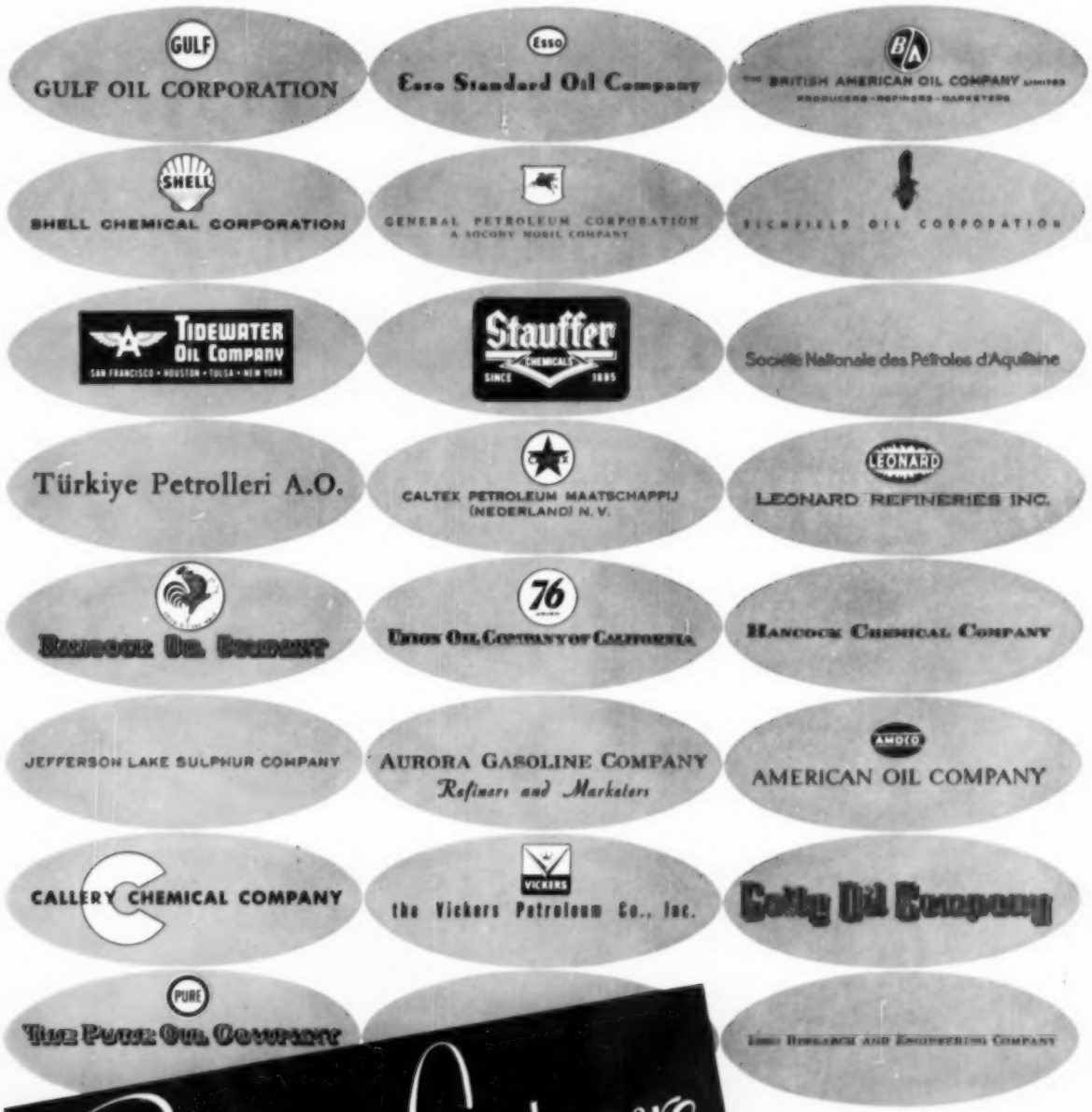
IBM Questionnaire has elicited gratifying cooperation . . . We now have in the office, it is estimated, 10,000 to 11,000 of the original 16,000 questionnaires sent out . . . . A little bit more about the idea behind the questionnaire probably ought to be explained at this time . . . The basic idea is that of rendering more service to members . . . In asking for help with Institute activities, we should know what areas the members are concerned with so that notices of meetings, selection of committeemen, etc., may reflect more accurately a man's interest . . . The new system will make possible more detail and better statistics in any future surveys . . . it will enable directories to be issued more frequently and at less expense . . . it will facilitate billing & the recording of payments . . . . We also plan to address the Institute magazines from these same cards . . . Some question has arisen in members' minds as to why two initials are insisted on & why full first names cannot be used . . . The reason is that the cards must be alphabetized & a machine must alphabetize on a certain column . . . Therefore room is left for only two initials before the column reserved for the first letter of the last name . . . Alphabetization will be done on the first six letters of every last name . . . Those who think about it will immediately suggest that the last name should have come first to allow room for the initials at a different spot, but once again the initials would then have to fall into certain columns in order that alphabetization of a group of names such as Smith would not result in Z. Z. Smith's preceding A. A. Smith . . . As of now the Institute office looks like a snowstorm of questionnaires, & staff members & families are devoting week ends to the coding, identification, & recording of them . . . But don't get us wrong; we are not complaining . . . . We expect to issue the **directory** this summer on a request basis . . . Anyone wishing a directory should write to the Institute offices & his name will be put on the list . . . We do not expect the first or even the second directory to be without errors, owing to the inherent nature of errors . . . They creep into everything, as some of you who have commented on the questionnaire have pointed out. **George Granger Brown** has come through a complicated operation and I know all his friends in the Institute will be pleased to hear that he is returning gradually to his activities as dean of engineering at the University of Michigan . . . George, a past President, has been Treasurer of the Institute since 1953.

Council Meeting at White Sulphur Springs saw the appointment of the 1957 **liaison Council members for Local Sections** . . . By now each liaison member should have written to the Local Sections he represents to tell them of this fact . . . Any Local Section officer who wants a list of the liaison members should drop us a note . . . . Council also voted to appoint George Martin Brown of Northwestern University as general chairman of the **Heat Transfer Conference,** at which A.I.Ch.E. will be host, to be held at Northwestern University in August, 1958 . . . Alan Foust has since then been appointed by the Heat Transfer group of the Program Committee as program chairman for this meeting . . . . A.I.Ch.E. members having papers in this area are asked to get in touch with Alan Foust at Lehigh University so that he may consider them for this meeting . . . . Annual dues of **Affiliates** were changed slightly . . . In the past, Affiliates, whatever their age, were asked to pay the same dues as Members, $21 . . . Associate Members under 35 years of age of course pay $14 & several members in recent months have suggested that Affiliates be given the same privilege if under 35 . . . This was considered by Council according to the provisions of the Constitution that one meeting be given to the Constitution and By-laws Committee for proper drafting of words . . . & on the second reading at the White Sulphur Springs Meeting the change was accepted by Council . . . This will be put into effect immediately . . . . The **New York Section** of the A.I.Ch.E. just recently turned out a publication on requirements of New York's professional-engineering examination & they are sponsoring a review course with other local engineering groups in New York . . . The mimeographed memo goes into the requirements, tells where application forms may be obtained, gives requirements for admission to the examination, tells what passing grades are & also summarizes the review courses available in the local area . . . This was done last year some time & we sent copies to all Local Section chairmen thinking that they too might be interested in the same technique.

* * *

The Institute staff was shocked and saddened by the accidental death of Angela Polito on April second. She was one of the happiest and most cheerful assistants we had in the Editorial Department, and we shall miss her. She was editorial assistant on the *A.I.Ch.E. Journal.*

—F.J.V.A.



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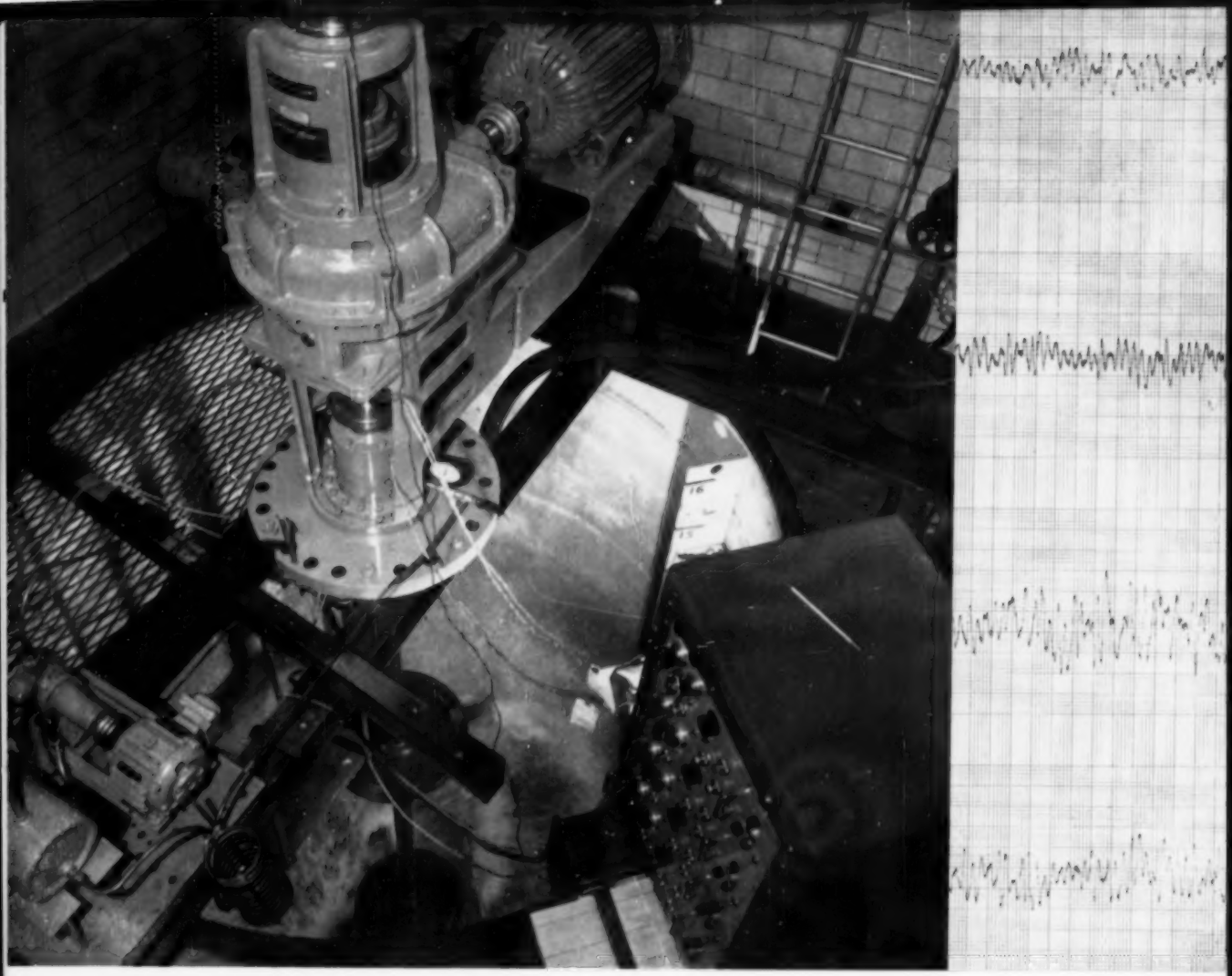

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